3.4 Marine Mammals

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3.4 MARINE MAMMALS

MARINE MAMMALS SYNOPSIS

The United States Department of the Navy considered all potential stressors, and analyzed the following for marine mammals:

- Acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise)
- Energy (electromagnetic devices)
- Physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices)
- Entanglement (fiber optic cables and guidance wires, and decelerators/parachutes)
- Ingestion (munitions and military expended materials other than munitions)
- Secondary (impacts associated with sediments and water quality)

Preferred Alternative (Alternative 1)

- Acoustic: Pursuant to the Marine Mammal Protection Act (MMPA), the use of sonar and other active acoustic sources, and underwater explosives may result in mortality, Level A harassment, or Level B harassment of certain marine mammals. The use of swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise are not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammals. Pursuant to the Endangered Species Act (ESA), the use of sonar and other active acoustic sources may affect and is likely to adversely affect certain ESA-listed marine mammals. The use of underwater explosives may affect, but is not likely to adversely affect marine mammals. Weapons firing, launch, and impact noise; vessel noise; and aircraft noise may affect but are not likely to adversely affect certain ESA-listed marine mammals. Swimmer defense airguns would have no effect on any ESA-listed marine mammal[1].
- Energy: Pursuant to the MMPA, the use of electromagnetic devices is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammals. Pursuant to the ESA, the use of electromagnetic devices may affect but is not likely to adversely affect certain ESA-listed marine mammals.
- Physical Disturbance and Strike: Pursuant to the MMPA, the use of vessels may result in mortality or Level A harassment of certain marine mammal species but is not expected to result in Level B harassment. The use of in-water devices, military expended materials, and seafloor devices is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, vessel use may affect and is likely to adversely affect certain ESA-listed species. The use of in-water devices and military expended materials may affect but is not likely to adversely affect certain marine mammal species. The use of seafloor devices would have no effect on any ESA-listed marine mammal.
- Entanglement: Pursuant to the MMPA, the use of fiber optic cables, guidance wires, and decelerators/parachutes is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, the use of fiber optic cables and guidance wires, and decelerators/parachutes may affect but is not likely to adversely affect certain ESA-listed marine mammals.
- Ingestion: Pursuant to the MMPA, the potential for ingestion of all types of military expended materials is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, the potential for ingestion of all types of military expended materials may affect but is not likely to adversely affect certain ESA-listed marine mammals.
- Secondary: Pursuant to the MMPA, secondary stressors are not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, secondary stressors may affect but are not likely to adversely affect certain ESA-listed marine mammals.

[1] There is no marine mammal critical habitat in the Study Area.

3.4.1 INTRODUCTION

This section provides the analysis of potential impacts to marine mammals that are found in the Mariana Islands Training and Testing (MITT) Study Area (Study Area). Section 3.4 (Marine Mammals) provides a synopsis of the United States (U.S.) Department of the Navy's (Navy's) determination of impacts from the proposed action on marine mammals. Section 3.4.2 (Affected Environment) provides an introduction to the species that occur in the Study Area. The complete analysis and summary of potential impacts of the proposed action on marine mammals are found in Sections 3.4.3 (Environmental Consequences) and 3.4.4 (Analysis of Effects to Marine Mammals), respectively.

Marine mammals are a diverse group of approximately 130 species worldwide. Most live predominantly in the marine habitat, although some species, such as seals, spend time in terrestrial habitats or in some cases, in freshwater environments, such as certain freshwater dolphins (Jefferson et al. 2008; Rice 1998). The exact number of formally recognized marine mammal species changes periodically with new scientific understanding or findings (Rice 1998). Even the higher-level classification of marine mammals is controversial because the understanding of their origins and relationships continues to evolve (for a list of current species, see the formal list, *Marine Mammal Species and Subspecies,* maintained by the Society for Marine Mammalogy [Perrin et al. 2009a]).

Marine mammals are protected under the Marine Mammal Protection Act (MMPA), and some species receive additional protection under the Endangered Species Act (ESA). There are ESA-listed species known to occur in the region (Table 3.4-1); however, no critical habitat for marine mammals protected pursuant to the ESA has been designated within the MITT Study Area. Additionally, no Biologically Important Areas, as defined under 50 Code of Federal Regulations 216.191, have been designated by the National Marine Fisheries Service (NMFS) in the MITT Study Area. Within the framework of the MMPA, a marine mammal "stock" is defined as "a group of marine mammals of the same species or smaller taxon [species] in a common spatial arrangement that interbreed when mature." For management purposes under the MMPA, a stock is considered an isolated population or group of individuals within a whole species that is found in the same area. However, in practice, recognized management stocks may fall short of this ideal because of a lack of information or other reasons and in some cases may even include multiple species, such as with certain beaked whales (Carretta et al. 2011). In the MITT Study Area in particular, where there is a paucity of systematic survey data, little is known about the stock structure of the majority of marine mammal species in the region and as a result, little is known about potential critical habitat in the area.

Prior to 2007 there was little information available on the occurrence of marine mammals in the Study Area, and much of what was known came from whaling records, stranding records, and anecdotal sighting reports. Eldredge (1991) compiled the first list of published and unpublished records for the greater Micronesia area, reporting 19 marine mammal species, later refining the list to 13 cetacean species thought to occur around Guam (Eldredge 2003). Wiles (2005) provided a list of birds and mammals recorded in the Micronesia area through March of 2005, including all records of marine mammals. Some sighting data are available from scientific surveys conducted in the western and central Pacific, although most of these efforts focused on waters off Japan, Taiwan, the Philippines, and lower latitude regions (Darling and Mori 1993; Dolar et al. 2006; Ohizumi et al. 2002; Wang et al. 2001; Yang et al. 1999), and provide limited to no data specific to the Study Area.

The Navy conducted the first comprehensive marine mammal survey of waters off the Mariana Islands from 13 January to 13 April 2007 (Fulling et al. 2011). The survey was conducted using systematic line transect survey protocol consistent with that used by the NMFS Southwest Fisheries Science Center

(Barlow 2003, 2006). Both visual and acoustic detection methods were used during the survey (Fulling et al. 2011). The Navy also conducted a 5-day aerial survey in August 2007, providing additional sighting data specific to the Study Area (Mobley 2007). Subsequent to the 2007 surveys, both the Navy and NMFS, Pacific Islands Fisheries Science Center have conducted dedicated small boat surveys around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), including: (1) surveys off Guam and Saipan from 9 February to 3 March 2010 (Ligon et al. 2011; Oleson and Hill 2010), (2) surveys off Guam from 17 February to 3 March 2011 (HDR 2011), (3) surveys off Guam and other islands in the CNMI from 26 August to 29 September 2011 (Hill et al. 2011), (4) surveys off Guam and Saipan from 15 to 29 March 2012 (HDR EOC 2012), and (5) surveys off Guam and other islands in the CNMI at various times between May and July 2012 (Hill et al. 2013). In addition, NMFS Pacific Islands Fisheries Science Center conducted a large vessel cetacean and oceanographic survey between Honolulu and Guam and within the Exclusive Economic Zones (EEZs) of Guam and CNMI from 20 January to 3 May 2010 (Oleson and Hill 2010). Information on the cetaceans sighted during the Navy and Pacific Islands Fisheries Science Center surveys are summarized within the species-specific subsections included in Section 3.4.2 (Affected Environment).

Table 3.4-1 provides a list of marine mammal species that have confirmed or potential occurrence in the MITT Study Area. Relevant information on their status, distribution, abundance, and ecology is presented in Section 3.4.2 (Affected Environment). For summaries of the general biology and ecology of marine mammals beyond the scope of this Environmental Impact Statement (EIS)/Overseas EIS (OEIS), see Rice (1998), Reynolds and Rommel (1999), Twiss and Reeves (1999), Hoelzel (2002), Berta et al. (2006), Jefferson et al. (2008), and Perrin et al. (2009b). Additional species profiles and information on the biology, life history, species distribution and conservation of marine mammals can also be found on the following organizations' websites:

- NMFS Office of Protected Resources (includes species distribution maps)
- Ocean Biographic Information System (OBIS)-Spatial Ecological Analysis of Megavertebrate Populations (SEAMAP) species profiles
- National Oceanic and Atmospheric Administration (NOAA) Cetacean Density and Distribution Mapping Working Group
- International Whaling Commission
- International Union for Conservation of Nature, Cetacean Specialist Group
- The Marine Mammal Commission
- Society for Marine Mammalogy

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Mariana Islands Training and Testing Study Area[1]

Species Name and Regulatory Status				Occurrence in Study Area[4]	
Common Name	**Scientific Name[1]**	**ESA Status[2]**	**MMPA Status[3]**	**Summer (June–Nov)**	**Winter (Dec–May)**
Order Cetacea					
Suborder Mysticeti (baleen whales)					
Humpback whale	*Megaptera novaeangliae*	Endangered	Depleted	Rare	Regular
Blue whale	*Balaenoptera musculus*	Endangered	Depleted	Rare	Rare
Fin whale	*Balaenoptera physalus*	Endangered	Depleted	Rare	Rare
Sei whale	*Balaenoptera borealis*	Endangered	Depleted	Rare	Regular
Bryde's whale	*Balaenoptera brydei/edeni*	-	-	Regular	Regular
Minke whale	*Balaenoptera acutorostrata*	-	-	Rare	Regular
Omura's whale	*Balaenoptera omurai*	-	-	Rare	Rare
Suborder Odontoceti (toothed whales)					
Sperm whale	*Physeter macrocephalus*	Endangered	Depleted	Regular	Regular
Pygmy sperm whale	*Kogia breviceps*	-	-	Regular	Regular
Dwarf sperm whale	*Kogia sima*	-	-	Regular	Regular
Killer whale	*Orcinus orca*	-	-	Regular	Regular
False killer whale	*Pseudorca crassidens*	-	-	Regular	Regular
Pygmy killer whale	*Feresa attenuata*	-	-	Regular	Regular
Short-finned pilot whale	*Globicephala macrorhynchus*	-	-	Regular	Regular
Melon-headed whale	*Peponocephala electra*	-	-	Regular	Regular
Common bottlenose dolphin	*Tursiops truncatus*	-	-	Regular	Regular
Pantropical spotted dolphin	*Stenella attenuata*	-	-	Regular	Regular

[1] Little is known about the stock structure of the majority of marine mammal species in the region. Therefore, in this table there is no specific Study Area information on the stocks recognized and managed by NMFS. For those species for which stock information exists, it is included in the species-specific Status and Management summaries.

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Mariana Islands Training and Testing Study Area (continued)

Species Name and Regulatory Status				Occurrence in Study Area[4]	
Common Name	Scientific Name[1]	ESA Status[2]	MMPA Status[3]	Summer (June–Nov)	Winter (Dec–May)
Striped dolphin	*Stenella coeruleoalba*	-	-	Regular	Regular
Spinner dolphin	*Stenella longirostris*	-	-	Regular	Regular
Rough-toothed dolphin	*Steno bredanensis*	-	-	Regular	Regular
Fraser's dolphin	*Lagenodelphis hosei*	-	-	Regular	Regular
Risso's dolphin	*Grampus griseus*	-	-	Regular	Regular
Cuvier's beaked whale	*Ziphius cavirostris*	-	-	Regular	Regular
Blainville's beaked whale	*Mesoplodon densirostris*	-	-	Regular	Regular
Longman's beaked whale	*Indopacetus pacificus*	-	-	Regular	Regular
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	-	-	Rare	Rare

[1] Taxonomy follows Perrin et al. (2009a).
[2] ESA listing status from Carretta et al. (2013).
[3] All marine mammals are protected under the MMPA. Populations or stocks that have fallen below the optimum sustainable population level are depleted. Due to the paucity of survey data, little is known about the stock structure of species in the region.
[4] Regular = a species that occurs as a regular or usual part of the fauna of the area, regardless of how abundant or common it is; Rare = a species that occurs in the area only sporadically. Occurrence designations from the Navy's Mariana Islands Marine Resource Assessment (MRA; U.S. Department of the Navy 2005), updated with new information as described in U.S. Department of the Navy (2013a). The MRA compiles species occurrence information based on peer-reviewed papers, unpublished technical reports, and other information sources.
Notes: ESA = Endangered Species Act, MMPA = Marine Mammal Protection Act

3.4.1.1 Species Unlikely to Be Present in the Mariana Islands Training and Testing Study Area

The species carried forward for analysis are those likely to be found in the MITT Study Area based on the most recent data available, and do not include species that may have once inhabited or transited the area but have not been sighted in recent years (e.g., species which no longer occur in an area due to factors such as 19th century commercial exploitation). These species include the North Pacific right whale (*Eubalaena japonica*), the western subpopulation of gray whale (*Eschrichtius robustus*), short-beaked common dolphin (*Delphinus delphis*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), Hawaiian monk seal (*Neomonachus schauinslandi*), northern elephant seal (*Mirounga angustirostris*), and dugong (*Dugong dugon*), which have been excluded from subsequent analysis for the reasons explained below.

3.4.1.1.1 North Pacific Right Whale (*Eubalaena japonica*)

The likelihood of a North Pacific right whale being present in the Study Area is extremely low as this species has only been observed in the Bering Sea and Gulf of Alaska in recent years. The most recent estimated population for the North Pacific right whale is between 28 and 31 individuals and although this estimate may be reflective of a Bering Sea subpopulation, the total eastern North Pacific population is unlikely to be much larger (Wade et al. 2010). A right whale was last observed in the Maui Basin (Hawaiian waters) in April 1996 (Salden and Mickelsen 1999). Later that year (July 1996), this same whale was observed in the Bering Sea and observed again in 2000 and 2008–2010 (Kennedy et al. 2011). Rare sightings of individual animals are typical of historical sightings, such as those of a single right whale on three occasions between 25 March and 11 April 1979 in Hawaiian waters (Herman et al. 1980; Rowntree et al. 1980). Based on this information, it is highly unlikely for this species to be present in the Study Area; consequently, this species will not be considered in greater detail in the remainder of this analysis.

3.4.1.1.2 Gray Whale Western Subpopulation (*Eschrichtius robustus*)

Gray whales are geographically separated into two subpopulations based on their occurrence along the eastern and western coastlines of the North Pacific. The western subpopulation of gray whale was once considered extinct but now small numbers are known to exist, although their migration routes are poorly known (Weller et al. 2002). Previous sighting data suggested that the remaining population of western gray whale had a limited range extent between the Okhotsk Sea off the coast of Sakhalin Island and the South China Sea (Weller et al. 2002). However, recent long-term studies of radio-tracked whales indicate that the coastal waters of eastern Russia, the Korean Peninsula, and Japan are part of the migratory route (Weller et al. 2012). There is also photographic evidence of a match between a whale found off Sakhalin and the Pacific coast of Japan, more than 932 miles (mi.) (1,500 kilometers [km]) south of the Sakhalin feeding area (Weller et al. 2008). Further, photo-catalog comparisons of eastern and western North Pacific gray whale populations suggest that there is more exchange between the western and eastern populations than previously thought, since “Sakhalin” whales were found off Santa Barbara, California; British Columbia, Canada; and Baja California, Mexico (Weller et al. 2013). A 14-year old male western gray whale tagged off northeastern Sakhalin Island on 4 October 2010, was located in the northeast Pacific off Oregon on 5 February 2011 (Mate et al. 2011). Based on telemetry data, the whale migrated across the Okhotsk Sea, Bering Sea, and Gulf of Alaska to reach its last recorded position off the Oregon coast. While the migration route of this single animal does not preclude other migration routes, there currently are no data available to suggest that western gray whales would transit the Study Area when migrating from the western to eastern Pacific. There have only been 13 records of gray whales in Japanese waters since 1990 (Nambu et al. 2010). The Okhotsk Sea and Sakhalin Island are located far to the north off Russia, and the South China Sea begins approximately 1,458 nautical miles (nm) east of the MITT Study Area. Given what is known of their present range, nearshore affinity, and extralimital occurrence in tropical waters, it is highly unlikely that this species would be present in the Study Area (Reilly et al. 2000; Weller et al. 2002; Wiles 2005; Nambu et al. 2010); consequently, this species will not be considered in greater detail in the remainder of this analysis.

3.4.1.1.3 Short-Beaked Common Dolphin (*Delphinus delphis*)

The short-beaked common dolphin is found worldwide in temperate, tropical, and subtropical seas. The range of this species may extend entirely across the tropical and temperate north Pacific (Heyning and

Perrin 1994); however, this species prefers areas with large seasonal changes in surface temperature and thermocline depth (the point between warmer surface water and colder water) (Au and Perryman 1985). They are one of the most abundant species found in temperate waters off the U.S. west coast (Barlow and Forney 2007). In tropical seas, they are typically sighted in upwelling-modified waters such as those in the eastern tropical Pacific (Au and Perryman 1985; Ballance and Pitman 1998; Reilly 1990). The absence of known areas of major upwelling in the western tropical Pacific suggests that common dolphins will not be found there (Hammond et al. 2008).

3.4.1.1.4 Indo-Pacific Bottlenose Dolphin (*Tursiops aduncus*)

The Indo-Pacific bottlenose dolphin generally occurs over shallow coastal waters on the continental shelf. Although typically associated with continental margins, they do occur around oceanic islands; however, the MITT Study Area is not included in their known geographic range, and there are no documented sightings there (Hammond et al. 2008). Miyashita (1993) reported that all of his sightings of bottlenose dolphins in the western Pacific were of a larger, unspotted type (presumably the bottlenose dolphin, as opposed to the similar Indo-Pacific bottlenose dolphin). Because the Indo-Pacific bottlenose dolphin is considered to be a species associated with continental margins, it does not appear to occur around offshore islands great distances from a continent, such as the Marianas. Given the low likelihood of this species occurrence in the Study Area, the Indo-Pacific bottlenose dolphin will not be considered in the remainder of this analysis.

3.4.1.1.5 Hawaiian Monk Seal (*Monachus schauinslandi*)

The likelihood of a Hawaiian monk seal being present in the Study Area is extremely low. There are no confirmed records of Hawaiian monk seals in the Micronesia region; however, Reeves et al. (1999) and Eldredge (1991, 2003) have noted occurrence records for unidentified seals species in the Marshall and Gilbert islands. It is possible that Hawaiian monk seals wander from the Hawaiian Islands to appear at the Marshall or Gilbert Islands in the Micronesia region (Eldredge 1991). However, the Marshall Islands are located approximately 1,180 mi. (1,900 km) from Guam and the Gilbert Islands are located even farther to the east. Given the extremely low likelihood of this species occurrence in the Study Area, this species will not be considered in greater detail in the remainder of this analysis.

3.4.1.1.6 Northern Elephant Seal (*Mirounga angustirostris*)

Northern elephant seals are common on island and mainland haul-out sites in Baja California, Mexico north through central California. Elephant seals spend several months at sea feeding and travel as far north as the Gulf of Alaska and forage in the mid-Pacific as far south as approximately 40 degrees north (°N) latitude. Vagrant individuals do sometimes range to the western north Pacific. The most far-ranging individual appeared on Nijima Island off the Pacific coast of Japan in 1989 (Kiyota et al. 1992). Although elephant seals may wander great distances it is very unlikely that they would travel to Japan and then continue traveling to the Study Area. Given the extremely low likelihood of this species occurrence in the Study Area, this species will not be considered in greater detail in the remainder of this analysis.

3.4.1.1.7 Dugong (*Dugong dugon*)

The likelihood of a dugong being present in the Study Area is extremely low. This species inhabits nearshore shallow water locations (Davis 2004). A total of 27 individuals were counted during the course of aerial surveys at Palau in 2003. This is the only location in the Micronesia region with a dugong population (Davis 2004), and Palau is located approximately 680 nm from Guam. The likelihood of a dugong occurring in the Study Area is extremely low; therefore, this species will not be considered in greater detail in the remainder of this analysis.

3.4.2 Affected Environment

Four main types of marine mammals are generally recognized: cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses; none of which are expected to occur in the Study Area), sirenians (manatees, dugongs, and sea cows; none of which are expected to occur in the Study Area), and several species of marine carnivores (marine otters and polar bears; none of which occur in the Study Area) (Jefferson et al. 2008; Rice 1998).

The Order Cetacea is divided into two suborders. The toothed whales, dolphins, and porpoises (suborder Odontoceti) range in size from slightly longer than 3 feet (ft.) (1 meter [m]) to more than 60 ft. (18 m) and have teeth, which they use to capture and consume individual prey. The baleen whales (suborder Mysticeti) are universally large (more than 15 ft. [4.6 m] as adults). They are called baleen whales because, instead of teeth, they have a fibrous structure made of keratin that is suspended from their upper jaws and is called baleen. Keratin is a type of protein similar to that found in human fingernails. The baleen enables the whales to filter and trap food from the water for feeding. They are batch feeders that use baleen instead of teeth to engulf, suck, or skim large numbers of small prey from the water or ocean floor sediments (Heithaus and Dill 2008). Detailed reviews of the different groups of cetaceans can be found in Perrin et al. (2009b).

The different feeding strategies between mysticetes and odontocetes affect their distribution and occurrence patterns. Cetaceans inhabit virtually every marine environment in the Study Area, from coastal waters to open ocean environments of the Pacific Ocean. Their distribution is influenced by a number of factors, but primary among these are patterns of major ocean currents, which, in turn, affect prey productivity. The continuous movement of water from the ocean bottom to the surface creates a nutrient-rich, highly productive environment for marine mammal prey (Jefferson et al. 2008). For most cetaceans, prey distribution, abundance, and quality largely determine where they occur at any specific time (Heithaus and Dill 2008). Most of the large cetaceans are migratory, but many small cetaceans do not migrate in the strictest sense. Instead, they undergo seasonal dispersal, or shifts in density (e.g., Forney and Barlow 1998). For recent summaries of the general biology and ecology of marine mammals, beyond the scope of this section, see Reynolds and Rommel (1999), Twiss and Reeves (1999), Hoelzel (2002), Berta et al. (2006), Jefferson et al. (2008), and Perrin et al. (2009b).

3.4.2.1 Group Size

Many species of marine mammals, particularly odontocetes, are highly social animals that spend much of their lives living in groups or schools ranging from several to several thousand individuals. Similarly, aggregations of baleen whales may form during particular breeding or foraging seasons, although they do not persist through time as a social unit. Group behavior is important for the purposes of mitigation and monitoring because larger groups are easier to detect. In addition, group size is an important consideration when conducting acoustic exposure analyses. A comprehensive and systematic review of relevant published and unpublished literature was conducted and the results were compiled into a Technical Report (Watwood and Buonantony 2012) that includes tables of group size information by species along with relevant citations.

3.4.2.2 Diving

Some species of marine mammals have developed specialized adaptations to allow them to make deep dives lasting over an hour, primarily for the purpose of foraging on deep-water prey such as squid. Other species spend the majority of their lives close to the surface, and make relatively shallow dives for shorter durations. The diving behavior of a particular species or individual has implications for the ability to detect them for mitigation and monitoring. In addition, their relative distribution through the water column is an important consideration when conducting acoustic exposure analyses. Information and data on diving behavior for each species of marine mammal were compiled and summarized in a Technical Report (Watwood and Buonantony 2012) that provides the detailed summary of time at depth.

3.4.2.3 Vocalization and Hearing of Marine Mammals

All marine mammals that have been studied can produce sounds and use sounds to forage; orient and navigate; monitor their environment; detect and respond to predators; and socially interact with others. Measurements of marine mammal sound production and hearing capabilities provide some basis for assessment of whether exposure to a particular sound source may affect a marine mammal behaviorally or physiologically. Marine mammal hearing abilities are quantified using live animals either via behavioral audiometry or electrophysiology (see Au 1993; Nachtigall et al. 2007; Schusterman 1981; Wartzok and Ketten 1999). Behavioral audiograms, which are plots of animals' exhibited hearing threshold versus frequency, are obtained from captive, trained live animals using standard testing procedures with appropriate controls, and are considered to be a more accurate representation of a subject's hearing abilities. Behavioral audiograms of marine mammals are difficult to obtain because many species are too large, too rare, and too difficult to acquire and maintain for experiments in captivity.

Electrophysiological audiometry measures small electrical voltages produced by neural activity when the auditory system is stimulated by sound. The technique is relatively fast, does not require a conscious response, and is routinely used to assess the hearing of newborn humans. Hearing response in relation to frequency for both methods of evaluating hearing ability is a generalized U-shaped curve or audiogram showing the frequency range of best sensitivity (lowest hearing threshold) and frequencies above and below with higher threshold values.

Consequently, our understanding of a species' hearing ability may be based on the behavioral audiogram of a single individual or a small group of animals. In addition, captive animals may be exposed to local ambient sounds and other environmental factors that may impact their hearing abilities whether positively or negatively, and may not accurately reflect the hearing abilities of free-swimming animals (Houser et al. 2008). For animals not available in captive or stranded settings (including large whales and rare species), estimates of hearing capabilities are made based on morphology and neuroanatomy structures, vocal characteristics, and extrapolations from related species.

Direct measurement of hearing sensitivity exists for approximately 25 of the nearly 130 species of marine mammals. Table 3.4-2 provides a summary of sound production and general hearing capabilities for marine mammal species in the Study Area (note that values in this table are not meant to reflect absolute possible maximum ranges, rather they represent the best known ranges of each functional hearing group). For purposes of the analyses in this document, marine mammals are arranged into the following functional hearing groups based on their generalized hearing sensitivities (note that these categories are not the same as the sonar source categories described in Chapter 2, Description of Proposed Action and Alternatives) high-frequency cetaceans, mid-frequency cetaceans, and low-frequency cetaceans (mysticetes).

Note that frequency ranges for high-, mid-, and low-frequency cetacean hearing differ from the frequency range categories defined using similar terms to describe active sonar systems. For discussion of all marine mammal functional hearing groups and their derivation see Finneran and Jenkins (2012).

Table 3.4-2: Hearing and Vocalization Ranges for All Marine Mammal Functional Hearing Groups and Species Potentially Occurring within the Study Area

Functional Hearing Group	Species Which May Be Present in the Study Area	Sound Production[1]		General Hearing Ability Frequency Range
		Frequency Range	Source Level (dB re 1 µPa @ 1 m)	
High-Frequency Cetaceans	*Kogia* Species (Dwarf Sperm Whale and Pygmy Sperm Whale)	100–200 kHz	120–205	200 Hz–180 kHz
Mid-Frequency Cetaceans	Sperm Whale, Beaked Whales (*Indopacetus*, *Mesoplodon*, and *Ziphius* species), Bottlenose Dolphin, Fraser's Dolphin, Killer Whale, False Killer Whale, Pygmy Killer Whale, Melon-headed Whale, Short-finned Pilot Whale, Risso's Dolphin, Rough-toothed Dolphin, Spinner Dolphin, Pantropical Spotted Dolphin, Striped Dolphin	100 Hz–100 kHz	118–236	150 Hz–160 kHz
Low-Frequency Cetaceans	Blue Whale, Bryde's Whale, Fin Whale, Humpback Whale, Minke Whale, Omura's Whale, Sei Whale	10 Hz–20 kHz	129–195	7 Hz–22 kHz

[1] Sound production levels and ranges and functional hearing ranges are generalized composites for all members of the functional hearing groups, regardless of their presence in this Study Area.

Sound production data adapted and derived from: Aburto et al. 1997; Kastelein et al. 2002; Kastelein et al. 2003; Marten 2000; McShane et al. 1995; Møhl et al. 2003; Philips et al. 2003; Richardson et al. 1995; Villadsgaard et al. 2007; Dunlop et al. 2013a

Hearing data adapted and derived from Southall et al. 2007.

These frequency ranges and source levels include social sounds for all groups and echolocation sounds for mid- and high-frequency groups.

Notes: dB re 1 µPa at 1 m = decibels (dB) referenced to (re) 1 micropascal (µPa) at 1 meter (m), Hz = Hertz, kHz = kilohertz

3.4.2.3.1 High-Frequency Cetaceans

Marine mammals within the high-frequency cetacean functional hearing group are all odontocetes (toothed whales; suborder: Odontoceti) and includes eight species and subspecies of porpoises (family: Phocoenidae); dwarf and pygmy sperm whales (family: Kogiidae); six species and subspecies of river dolphins; the franciscana; and four species of cephalorhynchus. The following members of the high-frequency cetacean group are present in the Study Area: dwarf sperm whale (*Kogia sima*) and pygmy sperm whale (*K. breviceps*). Functional hearing in high-frequency cetaceans occurs between approximately 200 Hertz (Hz) and 180 kilohertz (kHz) (Southall et al. 2007).

Sounds produced by high-frequency cetaceans range from approximately 100–200 kHz with source levels of 120–205 decibels (dB) referenced to (re) 1 micropascal (µPa) at 1 m (Richardson et al. 1995; Verboom and Kastelein 2003; Villadsgaard et al. 2007). Recordings of sounds produced by dwarf and pygmy sperm whales consist almost entirely of the click/pulse type (Marten 2000). High-frequency cetaceans also generate specialized clicks used in biosonar (echolocation) at frequencies above 100 kHz that are used to detect, localize and characterize underwater objects such as prey (Richardson et al. 1995).

An electrophysiological audiometry measurement on a stranded pygmy sperm whale indicated best sensitivity between 90 and 150 kHz (Ridgway and Carder 2001).

3.4.2.3.2 Mid-Frequency Cetaceans

Marine mammals within the mid-frequency cetacean functional hearing group are all odontocetes, and include the sperm whale (family: Phystereidae); 32 species and subspecies of dolphins (family: Delpinidae), the beluga and narwhal (family: Monodontidae), and 19 species of beaked and bottlenose whales (family: Ziphiidae). The following members of the mid-frequency cetacean group are present or have a reasonable likelihood of being present in the Study Area: sperm whale (*Physeter macrocephalus*), killer whale (*Orcinus orca*), false killer whale (*Pseudorca crassidens*), pygmy killer whale (*Feresa attenuata*), short-finned pilot whale (*Globicephala macrorhynchus*), melon-headed whale (*Peponocephala electra*), common bottlenose dolphin (*Tursiops truncatus*), pantropical spotted dolphin (*Stenella attenuata*), striped dolphin (*S. coeruleoalba*), spinner dolphin (*S. longirostris*), rough-toothed dolphin (*Steno bredanensis*), Fraser's dolphin (*Lagenodelphis hosei*), Risso's dolphin (*Grampus griseus*), and beaked whales (*Indopacetus, Mesoplodon*, and *Ziphius* species). Functional hearing in mid-frequency cetaceans is conservatively estimated to be between approximately 150 Hz and 160 kHz (Southall et al. 2007).

Hearing studies on cetaceans have focused primarily on odontocete species (Houser and Finneran 2006; Kastelein et al. 2002; Nachtigall et al. 2005; Szymanski et al. 1999; Yuen et al. 2005). Hearing sensitivity has been directly measured for a number of mid-frequency cetaceans, including Atlantic white-sided dolphins (*Lagenorhynchus acutus*) (Houser et al. 2010), common dolphins (Houser et al. 2010), Atlantic bottlenose dolphins (Johnson 1967; Finneran 2010), Indo-Pacific bottlenose dolphins (Houser et al. 2008), Black Sea bottlenose dolphins (Popov et al. 2007), striped dolphins (Kastelein et al. 2003), white-beaked dolphins (*Lagenorhynchus albirostris*) (Nachtigall et al. 2008), Risso's dolphins (Nachtigall et al. 2005), belugas (*Delphinapterus leucas*) (Finneran et al. 2005; White et al. 1978), long-finned pilot whales (*Globicephala melas*) (Pacini et al. 2010), false killer whales (Yuen et al. 2005), killer whales (Szymanski et al. 1999), Gervais' beaked whales (*Mesoplodon europaeus*) (Finneran and Schlundt 2009; Finneran et al. 2009), and Blainville's beaked whales (*M. densirostris*) (Pacini et al. 2011).

All audiograms exhibit the same general U-shape, with a wide nominal hearing range between approximately 150 Hz–160 kHz.

In general, odontocetes produce sounds across the widest band of frequencies. Their social vocalizations range from a few hundreds of hertz to tens of kilohertz (Southall et al. 2007) with source levels in the range of 100–170 dB re 1 µPa at 1 m (see Richardson et al. 1995). As mentioned earlier, they also generate specialized clicks used in echolocation at frequencies above 100 kHz that are used to detect, localize and characterize underwater objects such as prey (Au 1993). Echolocation clicks have source levels that can be as high as 229 dB re 1 µPa peak-to-peak (Au et al. 1974).

3.4.2.3.3 Low-Frequency Cetaceans

Marine mammals within the low-frequency functional hearing group are all mysticetes. This group is comprised of 13 species and subspecies of mysticete whales in six genera: *Eubalaena, Balaena, Caperea, Eschrichtius, Megaptera*, and *Balaenoptera*. The following members of the low-frequency cetacean group (mysticetes) are present or have a reasonable likelihood of being present in the Study Area: humpback (*Megaptera novaeangliae*), blue (*Balaenoptera musculus*), fin (*B. physalus*), sei (*B. borealis*), Bryde's (*B. edeni*), minke (*B. acutorostrata*), and Omura's (*B. omurai*) whales. Functional hearing in low-frequency cetaceans is conservatively estimated to be between approximately 7 Hz and 22 kHz (Southall et al. 2007).

Because of animal size and availability of live specimens, direct measurements of mysticete whale hearing are unavailable, although there was one effort to measure hearing thresholds in a stranded grey whale (Ridgway and Carder 2001). Because hearing ability has not been directly measured in these species, it is inferred from vocalizations, ear structure, and field observations. Vocalizations are audible somewhere in the frequency range of production, but the exact range cannot be inferred (Southall et al. 2007). Ketten (2014) developed predicted audiograms for blue whales and minke whales indicating the species are most sensitive to frequencies between 1 and 10 kHz, and Ketten and Mountain (2014) produced a predicted humpback whale audiogram using a mathematical model based on the internal structure of the ear. Estimated sensitivity was from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 6 kHz.

Mysticete cetaceans produce low-frequency sounds that range in the tens of Hz to several kHz that most likely serve social functions such as reproduction, but may serve an orientation function as well (Green et al. 1994). Humpback whales are the notable exception within the mysticetes, with some calls exceeding 10 kHz. These sounds can be generally categorized as low-frequency moans; bursts or pulses; or more complex songs (Edds-Walton 1997; Ketten 1997). Source levels of most mysticete cetacean sounds range from 150 to 190 dB re 1 µPa at 1 m (see Richardson et al. 1995).

3.4.2.4 General Threats

Marine mammal populations can be influenced by various factors and human activities. These factors can affect marine mammal populations directly, by activities such as hunting and whale watching, or indirectly, through reduced prey availability or lowered reproductive success of individuals. Twiss and Reeves (1999) provide a general discussion of marine mammal conservation.

Marine mammals are influenced by natural phenomena, such as storms and other extreme weather patterns. Generally, not much is known about how large storms and other weather patterns affect marine mammals, other than that mass strandings (when two or more marine mammals become beached or stuck in shallow water) sometimes coincide with hurricanes, typhoons, and other tropical storms (Marsh 1989; Rosel and Watts 2008). The global climate is changing and is having impacts on some populations of marine mammals (Salvadeo et al. 2010; Simmonds and Eliott 2009; Hazen et al. 2012). Climate change can affect marine mammal species directly through habitat loss (especially for species that depend on ice or terrestrial areas) and indirectly via impacts on prey, changing prey distributions and locations, and changes in water temperature (Hazen et al. 2012). Changes in prey can impact marine mammal foraging success, which in turn affects reproduction success, and survival. Climate change also may influence marine mammals through effects on human behavior, such as increased shipping and oil and gas extraction, resulting from sea ice loss (Alter et al. 2010).

Mass die offs of some marine mammal species have been linked to toxic algal blooms, that is, they consume prey that have consumed toxic plankton, such as die offs of California sea lions (*Zalophus californiaus*) and northern fur seals (*Callorhinus ursinus*) because of poisoning caused by the diatom *Pseudo-nitzschia* spp. (Doucette et al. 2006; Fire et al. 2008; Thomas et al. 2010; Johnson and Rivers 2009; Lefebrve et al. 2010; Torres de la Riva et al. 2009). All marine mammals have parasites that, under normal circumstances, probably do little overall harm, but under certain conditions, they can cause serious health problems or even death (Bull et al. 2006; Fauquier et al. 2009; Jepson et al. 2005). Disease affects some individuals (especially older animals), and occasionally disease epidemics can injure or kill a large percentage of the population (Keck et al. 2010; Paniz-Mondolfi and Sander-Hoffmann 2009). Recently the first case of morbillivirus in the central Pacific was documented for a whale (*Indopacetus pacificus*) at Homa Beach, Hana, Maui (West et al. 2012).

Human impacts on marine mammals have received much attention in recent decades, and include hunting (both commercial and native practices), fisheries interactions (such as gear entanglement or shootings by fishers), bycatch (accidental or incidental catch), indirect effects of fisheries through takes of prey species, ship strikes, chemical pollution, noise pollution, and general habitat deterioration or destruction.

Direct hunting, as in whaling and sealing operations, provided the original impetus for marine mammal management efforts and has driven much of the early research on cetaceans and pinnipeds (Twiss and Reeves 1999, Rocha et al. 2015). However, fishery bycatch is likely the most impactful problem presently and may account for the deaths of more marine mammals than any other cause (Hamer et al. 2010; Northridge 2008; Read 2008; Geijer and Read 2013). In 1994, the MMPA was amended to formally address bycatch. Estimates of bycatch in the Pacific declined by a total of 96 percent from 1994 to 2006 (Geijer and Read 2013). Cetacean bycatch declined by 85 percent from 342 in 1994 to 53 in 2006, and pinniped bycatch declined from 1,332 to 53 over the same time period. Another general threat to marine mammals is ship strikes, which are a growing issue for most marine mammals, particularly baleen whale species.

Chemical pollution is also of great concern, although for the most part, its effects on marine mammals are just starting to be understood (Aguilar Soto et al. 2008). Recently, the 5.5-year expedition of the *Odyssey* collected 955 biopsy samples from sperm whales around the world to provide a consistent baseline database of ocean contamination and to measure future effects (Ocean Alliance 2010). Chemical pollutants found in pesticides and other substances flow into the marine environment from human use on land and are absorbed into the bodies of marine mammals, accumulating in their blubber, internal organs, or are transferred to the young from mother's milk (Fair et al. 2010). Important factors that determine the levels of pesticides, heavy metals, and industrial pollutants that accumulate in marine mammals are gender (i.e., adult males have no way to transfer pesticides whereas females may pass pollutants to their calves through milk), habitat, and diet. Living closer to the source of pollutants and feeding on higher-level organisms increase the potential to accumulate toxins (Moon et al. 2010). The buildup of human-made persistent compounds in marine mammals not only increases their likelihood of contracting diseases or developing tumors but also compromises the function of their reproductive systems (Fair et al. 2010).

Oil and other chemical spills are a specific type of ocean contamination that can have damaging effects on some marine mammal species (see Matkin et al. 2008; Marine Mammal Commission 2011; Ackleh et al. 2012). Although information on effects of oil spills on marine mammals is limited, new information gained from study of the recent Deep Water Horizon oil spill in the Gulf of Mexico has provided insight on assessment of long-term effects (Ackleh et al. 2012; Marine Mammal Commission 2011), as has continued study of the 1989 Exxon Valdez in Prince William Sound, Alaska (see Matkin et al. 2008; Bodkin et al. 2012). In short, marine mammals can be affected directly by contact or ingestion of the oil, indirectly by activities during the containment and cleanup phases, and through long-term impacts on prey and habitat.

Habitat deterioration and loss is a major factor for almost all coastal and inshore species of marine mammals, especially those that live in rivers or estuaries, and it may include such factors as depleting a habitat's prey base and the complete loss of habitat (Kemp 1996; Smith et al. 2009; Ayres et al. 2012). In some locations, especially where urban or industrial activities or commercial shipping is intense, anthropogenic noise is also being increasingly considered as a potential habitat level stressor. Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. Noise may cause marine mammals to leave a habitat, impair their ability to communicate, or to cause stress (Hildebrand 2009; Tyack et al. 2011; Erbe et al. 2012; Rolland et al. 2012). Noise can cause behavioral disturbances, mask other sounds including their own vocalizations, may result in injury and in some cases, may result in behaviors that ultimately lead to death (National Research Council 2003, 2005; Nowacek et al. 2007; Southall et al. 2009a; Tyack 2009; Würsig and Richardson 2008). Anthropogenic noise is generated from a variety of sources including commercial shipping, oil and gas exploration and production activities, commercial and recreational fishing (including noise from fish finding sonar, fathometers, and acoustic deterrent and harassment devices), recreational boating and whale watching activities, offshore power generation, research (including sound from airguns, sonar, and telemetry), and military training and testing activities. Vessel noise in particular is a large contributor to noise in the ocean. Commercial shipping's contribution to ambient noise in the ocean has increased by as much as 12 dB over the last few decades (Hildebrand 2009; McDonald et al. 2008).

Marine mammals as a whole are subject to the various influences and factors delineated in this section. If additional specific threats to individual species within the Study Area are known, those threats are described below in the descriptive accounts of those species.

3.4.2.5 Humpback Whale (*Megaptera novaeangliae*)

3.4.2.5.1 Status and Management

Humpback whales are listed as depleted under the MMPA and endangered pursuant to the ESA. Based on evidence of population recovery in many areas, the species is being considered by NMFS for removal or down listing from the U.S. Endangered Species List (National Marine Fisheries Service 2009c).

In the Pacific, the stock structure of humpback whales is defined based on feeding areas because of the species' fidelity to feeding grounds (Carretta et al. 2013). NMFS has designated four stocks: (1) the Central North Pacific stock, with feeding areas from Southeast Alaska to the Alaska Peninsula; (2) the Western North Pacific stock, with feeding areas from the Aleutian Islands, Bering Sea, and Russia; (3) the California, Oregon, Washington, and Mexico stock, with feeding areas off the U.S. west coast; and (4) the American Samoa Stock, with feeding areas as far south as the Antarctic Peninsula (Carretta et al. 2013). Humpback whales in the MITT Study Area are most likely part of the Western North Pacific stock.

3.4.2.5.2 Geographic Range and Distribution

Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer on high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs (Herman et al. 2010). In the north Pacific, humpback whales feed primarily along the Pacific Rim from California to Russia (Barlow et al. 2011). Wintering (breeding) areas for North Pacific humpback whales include the coasts of Central America and Mexico, offshore islands of Mexico, Hawaii, and the western Pacific (Calambokidis et al. 2001). The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water (75 degrees Fahrenheit [°F]–82°F) (24 degrees Celsius [°C]–28°C) and relatively shallow, low-relief ocean bottom in protected areas, created by islands or reefs (Clapham 2000; Craig and Herman 2000; Smultea 1994). There is known to be some interchange of whales among different wintering grounds, for example, some of these interchanges have been noted between Hawaii and Japan and between Hawaii and Mexico (Darling et al. 1996; Calambokidis et al. 2001). Although interchange does occur among all the breeding stocks in the wintering grounds, it is not common (Calambokidis et al. 2001; Calambokidis et al. 1997). Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al. 2001; Clapham and Mattila 1990).

Humpback whales have been sighted during the Navy's routine aerial surveys of Farallon de Medinilla (FDM) on several occasions, including two sightings in 2006 (January and March), both close to the island, and another sighting in February of 2007, 18 mi. (29 km) north of Saipan (Vogt 2008). During a ship survey in the Study Area (January–April 2007), humpback whales were observed in both deep (2,625–3,940 ft. [800–1,200 m]) and shallow (1,234 ft. [374 m]) waters northeast of Saipan (Fulling et al. 2011). Acoustic detections of humpback song were also made during these sightings as well as on other occasions (Fulling et al. 2011). These observations suggest that there could be a small wintering population of humpback whales in or transiting during migration through the MITT Study Area, although additional research is needed for confirmation (Fulling et al. 2011; Ligon et al. 2011).

3.4.2.5.3 Population and Abundance

The overall abundance of humpback whales in the north Pacific was recently estimated at 21,808 individuals (coefficient of variation [CV] = 0.04; this is an indicator of uncertainty in the abundance estimate and describes the amount of variation with respect to the population mean, with a lower number representing less variation), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al. 2011). Data indicate the North Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year, so approximately doubling every 10 years (Calambokidis et al. 2008). Campbell et al (2015) reported no significant changes to the population of humpback whales in Southern California, indicating that the population is at least steady. Of the different stocks of humpback whales recognized in the Pacific Ocean, the Western North Pacific stock is the one most likely to be encountered within the MITT Study Area. The current population estimate for this stock is 938–1,107 animals (Allen and Angliss 2013).

3.4.2.5.4 Predator-Prey Interactions

Humpback whales feed on a variety of invertebrates and small schooling fish. The most common invertebrate prey are krill (tiny crustaceans); the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham and Mead 1999). Feeding occurs both at the surface and in deeper waters, wherever prey is abundant. Humpback whales are the only species of baleen whale that show strong evidence of cooperation when they feed in large groups (D'Vincent et al. 1985). It is believed that minimal feeding occurs in wintering grounds, although there have been scattered reports of single animals feeding (Salden 1989; Baraff et al. 1991).

This species is known to be attacked by both killer whales and false killer whales, as evidenced by tooth rake scars on their bodies and fins (Whitehead and Glass 1985).

3.4.2.5.5 Species-Specific Threats

Entanglement in fishing gear and other types of manmade lines pose a threat to individual humpback whales throughout the Pacific. Humpback whales from the Central North Pacific stock have been reported seriously injured and killed from entanglement in fishing gear while in their Alaskan feeding grounds (Neilson et al. 2009; Allen and Angliss 2010). From 2003 to 2007, an average of 3.4 humpback whales per year were seriously injured or killed due to entanglements with commercial fishing gear in Alaskan waters. This number is considered a minimum since observers have not been assigned to several fisheries known to interact with this stock and quantitative data on Canadian fishery entanglements are uncertain (Allen and Angliss 2010). With the exception of one reported stranding in 2007, for which stock identification is uncertain, there have been no strandings or sighting entanglement reports of individuals belonging to the Western North Pacific stock (Allen and Angliss 2011). However, effort in western Alaskan waters is low.

Between 2002 and 2006, the average annual mortality of Western North Pacific humpback whales from observed fisheries (Bering Sea/Aleutian Islands sablefish pot fishery) was 0.20 animals (Allen and Angliss 2011). Because stock identification is not certain, this estimate could include animals belonging to the Central North Pacific stock. However, since there are no data for mortalities resulting from Japanese or Russian fisheries, this estimate is considered a minimum regardless of uncertainties related to stock distinctions (Allen and Angliss 2011).

3.4.2.6 Blue Whale (*Balaenoptera musculus*)

3.4.2.6.1 Status and Management

The blue whale is listed as endangered pursuant to the ESA and as depleted under the MMPA. The NMFS considers blue whales found in the MITT Study Area as part of the Central North Pacific stock (Carretta et al. 2013) due to differences in call types with the Eastern North Pacific stock (Stafford et al. 2001; Stafford 2003).

3.4.2.6.2 Geographic Range and Distribution

The blue whale inhabits all oceans and typically occurs in nearshore and continental shelf waters; however, blue whales frequently travel through deep oceanic waters during migration (Mate et al. 1999). Most baleen whales spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Širović et al. 2004). Blue whales belonging to the Central Pacific stock feed in summer, south of the Aleutians and in the Gulf of Alaska, and migrate to wintering grounds in lower latitudes in the western Pacific and less frequently to the central Pacific (Stafford et al. 2004; Watkins et al. 2000). There are no recent sighting records for the blue whale in the MITT Study Area, although this area is in the distribution range for this species (Reilly et al. 2008). The Pacific Islands Fisheries Science Center has deployed several High-frequency Acoustic Recording Packages (HARPs) to monitor marine mammals and ambient noise levels in U.S. EEZ waters off the Mariana Islands. Recordings from these instruments are currently being analyzed but it has been confirmed that blue whales have been acoustically detected (Oleson 2013); however, since blue whale calls can travel up to 621 mi. (1,000 km), it is unknown whether the animals were actually within the study area. Blue whales would be most likely to occur in the MITT Study Area during the winter.

3.4.2.6.3 Population and Abundance

Widespread whaling over the last century is believed to have decreased the blue whale population to approximately 1 percent of its pre-whaling population size (Širović et al. 2004, Branch et al. 2007, Rocha et al 2015). The best available abundance estimate for the Eastern North Pacific stock of blue whales is 1,647 (Carretta et al. 2014) and 1,400 animals for the Eastern Tropical Pacific (Wade and Gerrodette 1993). Data collected during a 2010 systematic surveys off Hawaii resulted in an abundance estimate of 81 blue whales within the Hawaiian Islands EEZ during summer and fall (Bradford et al. 2013). Although the majority of blue whales are expected to be at higher latitude feeding grounds during summer/fall, this is currently considered the best abundance estimate for the Central North Pacific stock (Carretta et al. 2014). Campbell et al (2015) reported no significant changes to the population of blue whales in Southern California, indicating that the population is at least steady.

The information available on the status and trend of blue whale populations precludes any conclusions on the extinction risks facing blue whales as a species, or particular populations of blue whales. The possible exception is the Eastern North Pacific blue whale stock, which may not have been subject to as much commercial whaling as other blue whale populations. Recent literature suggest that this population may be recovering to a stable level since the cessation of commercial whaling in 1971 despite the impacts of ship strikes, interactions with fishing gear, and increased levels of ambient sound in the Pacific Ocean (Monnahan et al. 2014a, Monnahan et al. 2014b, Campbell et al. 2015).No blue whales were detected during a 2007 winter survey of the Study Area (Fulling et al. 2011).

3.4.2.6.4 Predator-Prey Interactions

This species preys almost exclusively on various types of zooplankton, especially krill. They lunge feed and consume approximately 6 tons (5,500 kilograms [kg]) of krill per day (Mori and Butterworth 2004; Jefferson et al. 2008). They sometimes feed at depths greater than 330 ft. (100 m), where their prey maintains dense groupings (Acevedo-Gutiérrez et al. 2002).

Blue whales have been documented to be preyed on by killer whales (Jefferson et al. 2008; Pitman et al. 2007).

3.4.2.6.5 Species-Specific Threats

Blue whales are susceptible to both ship strikes and entanglement in fishing gear (Carretta et al. 2011); however, no specific data are available for the Central North Pacific stock (Calambokidis et al. 2009a; Berman-Kowalewski et al. 2010). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.7 Fin Whale (*Balaenoptera physalus*)

3.4.2.7.1 Status and Management

The fin whale is listed as endangered pursuant to the ESA and as depleted under the MMPA. Pacific fin whale population structure is not well known, and NMFS has designated three stocks of fin whale in the North Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2013). The International Whaling Commission recognizes two management stocks in the North Pacific: a single widespread stock in the North Pacific and a smaller stock in the East China Sea (Donovan 1991). Little is known about the stock structure of fin whales in the MITT Study Area.

3.4.2.7.2 Geographic Range and Distribution

Fin whales are found in all the world's oceans, typically between approximately 20°–75°N and south (S) latitudes (Calambokidis et al. 2008). In the northern hemisphere, most fin whales migrate seasonally from high latitude feeding areas in summer to low latitude breeding and calving areas in winter (Kjeld et al. 2006; MacLeod et al. 2006a). The fin whale is typically found in continental shelf and oceanic waters (Gregr and Trites 2001; Reeves et al. 2002). Globally, it tends to be aggregated in locations where populations of prey are most plentiful, irrespective of water depth, although those locations may shift seasonally or annually (Kenney et al. 1997; Notarbartolo-di-Sciara et al. 2003; Payne et al. 1990; Payne et al. 1986). Fin whales in the North Pacific spend the summer feeding along the cold eastern boundary currents (Perry et al. 1999, Campbell et al. 2015). Falcone and Schorr (2014) provide further evidence based on Southern California visual sighting records, photographic ID matches, and satellite tagging from 2006-2013 for a Southern California permanent or semi-permanent resident population of fin whales displaying seasonal distribution shifts within the region. In waters of the NorthwesternHawaiian Islands, fins whales have been recorded in the winter and spring months (Meigs et al. 2013).

Fin whales are typically not expected south of 20°N during summer, and less likely to occur near Guam (Miyashita et al. 1996; National Marine Fisheries Service 2006). Miyashita et al. (1996) presented a compilation of at-sea sighting results by species, from commercial fisheries vessels in the Pacific Ocean from 1964 to 1990. For fin whales in August, Miyashita et al. (2006) reported no sightings south of 20°N, and significantly more sightings north of 40°N. However, they also showed limited search effort south of 20°N. There were no fin whale sightings during the winter 2007 survey of the Study Area (Fulling et al. 2011). The Pacific Islands Fisheries Science Center has deployed several HARPs to monitor marine mammals and ambient noise levels in U.S. EEZ waters off the Mariana Islands. Recordings from these instruments are currently being analyzed but it has been confirmed that fin whales have been acoustically detected (Oleson et al. 2013).

3.4.2.7.3 Population and Abundance

In the north Pacific, the total pre-exploitation population size of fin whales is estimated at 42,000–45,000 whales (Ohsumi and Wada 1974). In 1973, fin whale abundance in the entire North Pacific basin was estimated between 13,620 and 18,680 whales (Ohsumi and Wada 1974). Moore and Barlow (2011) reported an increase in fin whale abundance from 1991-2008. Over a 10-year window from 2004-2013, Campbell et al (2015) reported no significant changes to the population of fin whales in Southern California, indicating that the population is at least steady. The lack of sighting data precludes an estimate of fin whale abundance specific to the MITT Study Area.

3.4.2.7.4 Predator-Prey Interactions

Fin whales prey on small invertebrates such as copepods as well as squid, and schooling fish, such as capelin, herring, and mackerel (Goldbogen et al. 2006; Jefferson et al. 2008).

The fin whale is not known to have a significant number of predators (Vidal and Pechter 1989). However, in regions where killer whales are abundant, some fin whales exhibit attack scars on their flippers, flukes, and flanks suggesting possible predation by killer whales (Aguilar 2008).

3.4.2.7.5 Species-Specific Threats

Fin whales are susceptible to both ship strikes and entanglement in fishing gear (Douglas et al. 2008; Carretta et al. 2011); however, no specific data are available for fin whales in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.8 Sei Whale (*Balaenoptera borealis*)

3.4.2.8.1 Status and Management

The sei whale is listed as endangered pursuant to the ESA and as depleted under the MMPA. The International Whaling Commission groups all of sei whales in the entire north Pacific Ocean into one stock (Donovan 1991). However, some mark-recapture, catch distribution, and morphological research, indicate that more than one stock exists; one between 175 degrees west (°W) and 155°W longitude, and another east of 155°W longitude (Masaki 1976, 1977). NMFS has designated three stocks of sei whale in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2013). Little is known about the stock structure of sei whales in the MITT Study Area.

3.4.2.8.2 Geographic Range and Distribution

Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. Sei whales spend the summer feeding in high latitude subpolar latitudes and return to lower latitudes to calve in winter. On feeding grounds, their distribution is largely associated with oceanic frontal systems (Horwood 1987). Characteristics of preferred breeding grounds are unknown, since they have generally not been identified. Whaling data provide some evidence of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood 1987; Perry et al. 1999).

Various scientists have described the seasonal distribution of sei whales as occurring from 20°N to 23°N during the winter and from 35°N to 50°N during the summer (Horwood 2009; Masaki 1976, 1977; Smultea et al. 2010). However, sei whales were sighted during the 2007 survey of the Study Area, thus providing evidence that this species occurs south of 20°N in the winter (Fulling et al. 2011). They are considered absent or at very low densities in most equatorial areas.

Sei whales are most often found in deep oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins between banks and ledges (Best and Lockyer 2002; Gregr and Trites 2001; Kenney and Winn 1987; Schilling et al. 1992). These reports are consistent with observations during the 2007 survey of the Study Area, as sightings most often occurred in deep water 10,381–30,583 ft. (3,164–9,322 m). Most sei whale sightings were also associated with steep bathymetric relief (e.g., steeply sloping areas), including sightings adjacent to the Chamorro Seamounts east of the CNMI (Fulling et al. 2011). All confirmed sightings of sei whales were south of Saipan (approximately 15°N) with concentrations in the southeastern corner of the Study Area (Fulling et al. 2011). Sightings also often occurred in mixed groups with Bryde's whales. It is often difficult to distinguish sei whales from Bryde's whales at sea, and if a positive species identification cannot be made, sightings are typically categorized as sei/Bryde's whale.

3.4.2.8.3 Population and Abundance

In the north Pacific, the pre-exploitation sei whale population was estimated at 42,000 whales (Tillman 1977). The most current population estimate for sei whales in the entire north Pacific is 9,110 (Calambokidis et al. 2008). Sei whales were considered to be extralimital in the Study Area but during the 2007 systematic survey, sei whales were sighted on 16 occasions with a resulting abundance estimate of 166 individuals (coefficient of variation [CV] = 0.49) (Fulling et al. 2011).

3.4.2.8.4 Predator-Prey Interactions

Feeding occurs primarily around dawn, which appears to be correlated with vertical migrations of prey species (Horwood 2009). Unlike other rorquals, the sei whale skims to obtain its food, although it does some lunging and gulping similar to other rorqual species (Horwood 2009). In the north Pacific, sei whales feed on a diversity of prey, including copepods, krill, fish (specifically sardines and anchovies), and cephalopods (squids, cuttlefish, octopuses) (Horwood 2009; Nemoto and Kawamura 1977).

Sei whales, like other large baleen whales, are likely subject to occasional attacks by killer whales (Ford and Reeves 2008).

3.4.2.8.5 Species-Specific Threats

Sei whales, like other large baleen whales, are likely susceptible to both ship strikes and entanglement in fishing gear (Carretta et al. 2011); however, no specific data are available for sei whales in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.9 Bryde's Whale (*Balaenoptera edeni*)

3.4.2.9.1 Status and Management

The Bryde's whale is protected under the MMPA and is not listed pursuant to the ESA. The International Whaling Commission recognizes three management stocks of Bryde's whales in the north Pacific: (1) western north Pacific, (2) eastern north Pacific, and (3) east China Sea (Donovan 1991), although the biological basis for defining separate stocks of Bryde's whales in the central north Pacific is not clear (Carretta et al. 2010). In the most recent Stock Assessment Report, NMFS has designated two areas for Bryde's whale in the north Pacific: (1) waters in the eastern Pacific (east of 150°W and including the Gulf of California and waters off California), and (2) waters around Hawaii (Carretta et al. 2013). Little is known about the stock structure of Bryde's whales in the MITT Study Area.

3.4.2.9.2 Geographic Range and Distribution

Bryde's whales are found year-round in tropical and subtropical waters, generally not moving poleward of 40° in either hemisphere (Jefferson et al. 1993; Kato 2002). Limited shifts in distribution toward and away from the equator, in winter and summer, respectively, have been observed (Cummings 1985; Best 1996). Data suggest that winter and summer grounds partially overlap in the central north Pacific, from 5°S to 40°N (Kishiro 1996; Ohizumi et al. 2002). They have been reported to occur in both deep and shallow waters globally. Bryde's whales in some areas of the world are sometimes seen very close to shore and even inside enclosed bays (Baker and Madon 2007; Best et al. 1984). Bryde's whales are the most common baleen whales likely to occur in the Study Area (Eldredge 1991, 2003; Kishiro 1996; Miyashita et al. 1996; Okamura and Shimada 1999). Occurrence patterns are expected to be the same throughout the year.

Historical records show a consistent presence of Bryde's whales in the Mariana Islands. Miyashita et al. (1996) sighted Bryde's whales in the Mariana Islands during a 1994 survey, commenting that in the western Pacific these whales are typically only seen when surface water temperature was greater than 68°F (20°C) although Yoshida and Kato (1999) reported a preference for water temperatures between approximately 59° and 68°F (15° and 20°C). A single Bryde's whale washed ashore on Masalok Beach on Tinian in February, 2005 (Trianni and Tenorio 2012). There is also one reported stranding for this area that occurred in August 1978 (Eldredge 1991, 2003). During marine mammal monitoring activities for Valiant Shield 07, a single Bryde's whale was observed about 87 nm east of Guam at the edge of the Mariana Trench (Mobley 2007).

Bryde's whales were identified 18 times during the 2007 survey of the Study Area (Fulling et al. 2011). They were observed in groups of one to three, with several sightings including calves. Bryde's whales were sighted in deep waters, ranging from 8,363 to 24,190 ft. (2,534 to 7,330 m). Most sightings were associated with steep bathymetric relief (e.g., steeply sloping areas and seamounts), including sightings adjacent to the Chamorro Seamounts east of CNMI and over the West Mariana Ridge. There were several sightings in waters over and near the Mariana Trench, as well as in the southeast corner of the Study Area. Multi-species aggregations with sei whales were observed on several occasions (Fulling et al. 2011). As noted previously, Bryde's whales are often difficult to distinguish from sei whales at sea; if a positive species identification cannot be made, sightings are typically categorized as sei/Bryde's whale.

3.4.2.9.3 Population and Abundance

Little is known of population status and trends for most Bryde's whale populations. Based on Japanese and Soviet fishing records, the stock size of Bryde's whale in the north Pacific was estimated to decline from approximately 22,500 animals in 1,971 to 17,800 animals in 1977 (Tillman 1978). Based on line-transect estimates from the 2007 survey, an estimated 233 (CV = 0.45) Bryde's whales were present in the Study Area (Fulling et al. 2011).

3.4.2.9.4 Predator-Prey Interactions

Bryde's whales are lunge feeders and primarily feed on schooling fish. Prey includes anchovy, sardine, mackerel, herring, krill, and other invertebrates, such as pelagic red crab (Baker and Madon 2007; Jefferson et al. 2008; Nemoto and Kawamura 1977). Bryde's whales have been observed using "bubble nets" to herd prey (Jefferson et al. 2008; Kato and Perrin 2008). Bubble nets are used in a feeding strategy where the whales dive and release bubbles of air that float up in a column and trap prey inside where they lunge through the column to feed.

Bryde's whale is known to be prey for killer whales, as evidenced by an aerial observation of 15 killer whales attacking a Bryde's whale in the Gulf of California (Silber et al. 1990).

3.4.2.9.5 Species-Specific Threats

Bryde's whales are susceptible to both ship strikes and entanglement in fishing gear (Carretta et al. 2011); however, no specific data are available for Bryde's whales in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.10 Minke Whale (*Balaenoptera acutorostrata*)

Until recently, all minke whales were classified as the same species. Three subspecies of the common minke whale are now recognized: *Balaenoptera acutorostrata davidsoni* in the north Atlantic, *Balaenoptera acutorostrata scammoni* in the north Pacific (including the Study Area), and a third—formally unnamed but generally called the dwarf minke whale—that mainly occurs in the southern hemisphere (Arnold et al. 1987).

3.4.2.10.1 Status and Management

The minke whale is protected under the MMPA and is not listed pursuant to the ESA. The International Whaling Commission recognizes three stocks of minke whales in the north Pacific: (1) the Sea of Japan, (2) the rest of the western Pacific west of 180°N, and (3) one in the "remainder of the Pacific" (Donovan 1991). These broad designations basically reflect a lack of knowledge about the population structure of minke whales in the north Pacific (Carretta et al. 2011). NMFS has designated three stocks of minke whale in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2013). Little is known about the stock structure of minke whales in the MITT Study Area.

3.4.2.10.2 Geographic Range and Distribution

Minke whales are present in the north Pacific from near the equator to the Arctic (Horwood 1990; Jefferson et al. 1993). In the winter, minke whales are found south to within 2° of the equator (Perrin and Brownell 2002). There is no obvious migration from low-latitude, winter breeding grounds to high-latitude, summer feeding locations in the western North Pacific, as there is in the North Atlantic (Horwood 1990); however, there are some monthly changes in densities in both high and low latitudes (Okamura et al. 2001). Some coastal minke whales restrict their summer activities to exclusive home ranges (Dorsey 1983) and exhibit site fidelity to these areas between years (Borggaard et al. 1999).

Minke whales generally occupy waters over the continental shelf, including inshore bays, and even occasionally enter estuaries. However, records from whaling catches and research surveys worldwide indicate an open ocean component to the minke whale's habitat (Horwood 1990; Mellinger et al. 2000; Mitchell 1991; Roden and Mullin 2000; Slijper et al. 1964).

Due to the cryptic behavior of this species it is not unusual to have acoustic sightings with no visual confirmation (Rankin et al. 2007). Minke whale vocalizations in the Pacific Islands have been reported during the winter months, and in November during a 2002 survey of the U.S. EEZ waters around Hawaii, a minke whale was sighted while "off effort"[2] after the animal was detected acoustically (Barlow 2006; Rankin and Barlow 2005). Minke whales were the most frequently acoustically detected species of baleen whale during the 2007 survey of the Study Area and were mostly found in the southwestern area near the Mariana Trench (Fulling et al. 2011).

3.4.2.10.3 Population and Abundance

There are no population estimates for minke whales in the entire north Pacific, and despite confirmed sightings and acoustic detections, abundance estimates have not been made for the Hawaiian stock of minke whales (Carretta et al. 2014). Recent line-transect analyses of acoustic detections of minke whales during the 2007 survey of the Study Area resulted in an estimate of approximately 183–227 animals (Norris et al. 2011); however, methods for estimating density from acoustic detections are currently being developed and numerous assumptions are associated with the calculations. These estimates should thus be considered preliminary.

3.4.2.10.4 Predator-Prey Interactions

Similar to other rorquals, minke whales are "gulpers," or lunge feeders, often plunging through patches of shoaling fish or krill (Hoelzel et al. 1989; Jefferson et al. 2008). In the north Pacific, major food items include krill, Japanese anchovy, Pacific saury, and walleye pollock (Perrin and Brownell 2002; Tamura and Fujise 2002).

Minke whales are prey for killer whales (Ford et al. 2005); a common minke was observed being attacked by killer whales near British Columbia (Ford et al. 2005; Weller 2008).

3.4.2.10.5 Species-Specific Threats

Minke whales are susceptible to both ship strikes and entanglement in fishing gear (Carretta et al. 2011); however, no specific data are available for minke whales in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.11 Omura's Whale (*Balaenoptera omurai*)

3.4.2.11.1 Status and Management

Omura's whale is protected under the MMPA and is not listed under the ESA. Until recently, all medium-sized baleen whales were considered members of one of two species, *Balaenoptera edeni* (Bryde's whale) or *Balaenoptera borealis* (sei whale). However, at least three genetically-distinct types of these whales are now known, including the so-called pygmy or dwarf Bryde's whales (*Balaenoptera brydei*) (Kato and Perrin 2008; Rice 1998). In 2003, a new species, Omura's whale, was first described from records from the Philippines, eastern Indian Ocean, Indonesia, Sea of Japan, and the Solomon Islands (Wada et al. 2003). Whales in the Solomon Islands were found to be distinct from Bryde's whales found

[2] "Off effort" means the ship is not on a systematic survey line and/or specified survey conditions are not met (e.g., the sea state is too high) so species sightings made while off effort are not typically used to estimate abundance using line-transect methods. In this case, the ship presumably went off effort to investigate the minke whale acoustic detection.

in the offshore waters of the western north Pacific and the East China Sea (Wada and Numachi 1991; Yoshida and Kato 1999). Later it became evident that the term "pygmy Bryde's whale" had been mistakenly used for specimens of *Balaenoptera omurai* (Reeves et al. 2004). Given the general paucity of data on this species, nothing is known of the stock structure of Omura's whale.

3.4.2.11.2 Geographic Range and Distribution

Little is known of the geographic range of Omura's whale since few sightings of this species have been confirmed. Omura's whale is known to occur in the tropical and subtropical waters of the western Pacific and eastern Indian Oceans (Jefferson et al. 2008). It generally occurs alone or in pairs, and has been sighted primarily over the continental shelf in nearshore waters (Jefferson et al. 2008). It is possible that this species may occur in the Study Area, although there are no confirmed sightings to date.

3.4.2.11.3 Population and Abundance

There are currently no global estimates of the population size of Omura's whale. Ohsumi (1980) used sighting data to estimate an abundance of 1,800 animals for the Solomon Islands "Bryde's whale" stock; given the previous mistaken identity of the species, this estimate may relate to Omura's whale. Given the likelihood that some of the animals may have actually been Bryde's whales, and that the estimate was based on a small sample size, it is not considered reliable. There are no abundance estimates specific to the Study Area.

3.4.2.11.4 Predator-Prey Interactions

Little is known of the prey interactions of this species. Like other rorquals, Omura's whales are lunge feeders, and are assumed to feed on a variety of krill and fish (Hoelzel et al. 1989; Jefferson et al. 2008).

Similar to other baleen whales, it is likely that Omura's whales are subject to occasional attacks by killer whales.

3.4.2.11.5 Species-Specific Threats

Similar to other baleen whale species, Omura's whales are likely susceptible to both ship strikes and entanglement in fishing gear, although there are no specific data available for this species. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.12 Sperm Whale (*Physeter macrocephalus*)

3.4.2.12.1 Status and Management

The sperm whale has been listed as endangered since 1970 under the precursor to the ESA (National Marine Fisheries Service 2009d), and is depleted under the MMPA. The International Whaling Commission divided the north Pacific into two management regions to define a western and eastern stock of sperm whales; the boundary consists of a zigzag pattern that starts at 150°W at the equator, is at 160°W between 40 and 50°N, and ends up at 180°W north of 50°N (Donovan 1991). NMFS has designated three stocks of sperm whale in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2013). Little is known about the stock structure of sperm whales in the MITT Study Area.

3.4.2.12.2 Geographic Range and Distribution

Sperm whales are found throughout the North Pacific, and are distributed broadly from equatorial to polar waters (Whitehead et al. 2008). Mature female and immature sperm whales of both sexes are found in more temperate and tropical waters from the equator to around 45˚N throughout the year; these groups are rarely found at latitudes higher than 50˚N and 50˚S (Reeves and Whitehead 1997). In some tropical areas, sperm whales appear to be largely resident, with pods of females with calves remaining on the breeding grounds throughout the year (Rice 1989; Whitehead 2003; Whitehead et al. 2008). Sexually mature males join these groups throughout the winter. During the summer, mature male sperm whales are thought to move north into the Aleutian Islands, Gulf of Alaska, and the Bering Sea. In the northern hemisphere, "bachelor" groups (males typically 15–21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al. 2007).

Sperm whales show a strong preference for deep waters (Rice 1989; Whitehead 2003). Their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters. Although this species shows a preference for deep waters, in some areas adult males are reported to consistently frequent waters with bottom depths less than 330 ft. (100 m) and as shallow as 130 ft. (40 m) (Jefferson et al. 2008; Romero et al. 2001). Typically, sperm whale concentrations correlate with areas of high productivity. These areas are generally near drop offs and areas with strong currents and steep topography (Gannier and Praca 2007; Jefferson et al. 2008).

Sightings collected by Kasuya and Miyashita (1988) suggest that that there are two stocks of sperm whales in the western North Pacific, a northwestern stock with females that summer off the Kuril Islands and winter off Hokkaido and Sanriku, and the southwestern North Pacific stock with females that summer in the Kuroshio Current System and winter around the Bonin Islands. The males of these two stocks are found north of the range of the corresponding females, i.e., in the Kuril Islands/Sanriku/Hokkaido and in the Kuroshio Current System, respectively, during the winter.

Whaling records demonstrate sightings year-round in the Study Area (Townsend 1935). There are also two stranding records for this area (Eldredge 1991, 2003; Kami and Lujan 1976). During the Navy-funded survey in 2007, there were multiple sightings that included young calves and large bulls (Fulling et al. 2011). These findings are consistent with an earlier sighting of a group of sperm whales that included a newborn calf off the west coast of Guam (Eldredge 2003). During the 2007 survey, sperm whales were observed in waters 2,670–32,584 ft. (809–9,874 m) deep (Fulling et al. 2011). During a small boat survey around Guam and Saipan in February and early March of 2010, there were two sperm whale sightings: (1) a group of nine animals off Orote Point, Guam, inshore from the 1,640 ft. (500 m) isobath; and (2) a group of six animals northwest of Saipan in waters greater than 3,281 ft. (1,000 m) deep (Ligon et al. 2011). A group of 10 sperm whales was also sighted during small boat surveys off western Guam in waters approximately 3,940 ft. deep (1,200 m) on 19 March 2012 (HDR EOC 2012).

3.4.2.12.3 Population and Abundance

It is estimated that there are between 200,000 and 1,500,000 sperm whales worldwide (National Marine Fisheries Service 2010). A ship survey conducted in the eastern temperate North Pacific in spring of 1997 resulted in estimates of 26,300 (CV = 0.81)–32,100 (CV = 0.36) animals based on visual sightings or acoustic detections, respectively (Barlow and Taylor 2005).

The sperm whale was the most frequently sighted cetacean (21 sightings) during the 2007 survey with acoustic detections almost three times higher (61) than visual detections in the field (Norris et al. 2012). Post processing of the acoustic data resulted in 91 distinct localizations of individual sperm whales. Based on a preliminary analysis, the distribution of sperm whales appeared to be clustered in three main regions of the Study Area, the northeast, central, and southwest portions, with a few others in the trench and offshore regions (Norris et al. 2012). Line-transect abundance estimates derived from these survey data yielded an estimate of 705 (CV = 0.60) sperm whales in the Study Area (Fulling et al. 2011).

3.4.2.12.4 Predator-Prey Interactions

Sperm whales socialize for predator defense and foraging purposes. Sperm whales forage during deep dives that routinely exceed a depth of 1,314 ft. (398 m) and 30-minute duration (Watkins et al. 2002). Sperm whales feed on squid, other cephalopods, and bottom-dwelling fish and invertebrates (Davis et al. 2007; Marcoux et al. 2007; Rice 1989).

False killer whales, pilot whales, and killer whales have been documented harassing and on occasion attacking sperm whales (Arnbom et al. 1987; Palacios and Mate 1996; Pitman et al. 2001; Baird 2009).

3.4.2.12.5 Species-Specific Threats

Sperm whales are susceptible to entanglement in fishing gear, ingestion of marine debris, and ship strikes. In U.S. waters in the Pacific, sperm whales are known to have been incidentally taken in drift gillnet operations (Carretta et al. 2011). Interactions between longline fisheries and sperm whales in the northeast Pacific and Gulf of Alaska have also been reported (Hill and DeMaster 1999; Rice 1989; Sigler et al. 2008; Mathias et al. 2012). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.13 Pygmy Sperm Whale (*Kogia breviceps*)

There are two species of *Kogia* that could occur in the Study Area: the pygmy sperm whale (*Kogia breviceps*) and the dwarf sperm whale (*Kogia sima*). Before 1966 they were considered to be the same species until morphological distinction was shown (Handley 1966). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al. 2008).

3.4.2.13.1 Status and Management

The pygmy sperm whale is protected under the MMPA and is not listed pursuant to the ESA. NMFS recognizes two discrete non-contiguous stocks of pygmy sperm whales in the U.S. EEZ: (1) California, Oregon, and Washington; and (2) Hawaiian (Carretta et al. 2013). Little is known about the stock structure of pygmy sperm whales in the MITT Study Area.

3.4.2.13.2 Geographic Range and Distribution

Pygmy sperm whales have a worldwide distribution in tropical and temperate waters (Jefferson et al. 1993). The pygmy sperm whale appears to frequent more temperate habitats than the other *Kogia* species, which is more of a tropical species. For example, during boat surveys between 2000 and 2003 in the main Hawaiian Islands, the pygmy sperm was observed, but less commonly than the dwarf sperm whale (Baird 2005; Baird et al. 2003; Barlow et al. 2004). They are most often observed in waters along the continental shelf break and over the continental slope (e.g., Baumgartner et al. 2001; Baird 2005; McAlpine 2009). Little is known about possible migrations of this species. Pygmy sperm whales are difficult to photograph or tag, and thus, additional data are needed to be able to define migration routes or seasonality (Baird et al. 2011).

There were no *Kogia* species sighted during the 2007 survey of the Study Area (Fulling et al. 2011). However, this species is difficult to detect in high sea states and more than half of this survey was conducted in rough conditions (i.e., Beaufort sea states greater than 4). On 4 December 1997, a pygmy sperm whale was found stranded at Sugar Dock, Saipan (Trianni and Tenorio 2012). During marine mammal monitoring for Valiant Shield 07, a group of three *Kogia* (dwarf or pygmy sperm whales) was observed about 8 nm east of Guam (Mobley 2007).

3.4.2.13.3 Population and Abundance

Few abundance estimates have been made for this species, and too little information is available to obtain a reliable population estimate for pygmy sperm whales in the Western Pacific. There are no available population estimates for pygmy sperm whales in the Study Area.

3.4.2.13.4 Predator-Prey Interactions

Pygmy sperm whales feed on cephalopods and, less often, on deep-sea fishes and shrimps (Caldwell and Caldwell 1989; Santos et al. 2006; Beatson 2007). A recent study in Hawaiian waters showed cephalopods were the primary prey of pygmy sperm whales, making up 78.7 percent of prey abundance and 93.4 percent contribution by mass (West et al. 2009). Stomach samples revealed an extreme diversity of cephalopod prey, with 38 species from 17 different families (West et al. 2009).

Pygmy sperm whales have been documented to be prey to white sharks (Long 1991; Tirard et al. 2010) and are likely subject to occasional killer whale predation like other whale species.

3.4.2.13.5 Species-Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to pygmy sperm whales (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.14 Dwarf Sperm Whale (*Kogia sima*)

There are two species of *Kogia*: the pygmy sperm whale (discussed in Section 3.4.2.13, Pygmy Sperm Whale) and the dwarf sperm whale, which until recently had been considered to be the same species. Genetic evidence suggests that there might also be two separate species of dwarf sperm whales globally, one in the Atlantic and one in the Indo-Pacific (Jefferson et al. 2008). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Chivers et al. 2005; Jefferson et al. 2008).

3.4.2.14.1 Status and Management

The dwarf sperm whale is protected under the MMPA and is not listed pursuant to the ESA. NMFS recognizes two discrete non-contiguous stocks of dwarf sperm whales in the U.S. EEZ: (1) California, Oregon, and Washington; and (2) Hawaiian (Carretta et al. 2013). Little is known about the stock structure of dwarf sperm whales in the MITT Study Area.

3.4.2.14.2 Geographic Range and Distribution

Dwarf sperm whales have been observed in both outer continental shelf and more oceanic waters (MacLeod et al. 2004). Although the dwarf sperm whale appears to prefer more tropical waters than the pygmy sperm whale, the exact habitat preferences of this species are not well understood. Records of this species have been documented from the western Pacific (Taiwan) and the eastern Pacific (California) (Scott and Cordaro 1987; Sylvestre 1988; Wang et al. 2001; Wang and Yang 2006; Jefferson et al. 2008; Carretta et al. 2010).

There were no species of *Kogia* sighted during the 2007 survey of the Study Area (Fulling et al. 2011). However, similar to the pygmy sperm whale, this species is difficult to detect in high sea states and more than half of this survey was conducted in rough conditions (i.e., Beaufort sea states greater than 4). On 24 August 1993, a dwarf sperm whale was found stranded at San Jose Beach, Saipan (Trianni and Tenorio 2012). During marine mammal monitoring for Valiant Shield 07, a group of three *Kogia* (dwarf or pygmy sperm whales) was observed about 8 nm east of Guam (Mobley 2007). There was one sighting of a single dwarf sperm whale in the Marpi Reef area, northeast of Saipan, during small boat surveys conducted in August and early September of 2011 (Hill et al. 2011).

3.4.2.14.3 Population and Abundance

Few abundance estimates have been made for this species, and too little information is available to obtain a reliable population estimate for dwarf sperm whales in the Western Pacific. There are no available population estimates for dwarf sperm whales in the Study Area.

3.4.2.14.4 Predator-Prey Interactions

Dwarf sperm whales feed on cephalopods and, less often, on deep sea fishes and shrimps (Caldwell and Caldwell 1989; Sekiguchi et al. 1992). Dwarf sperm whales generally forage near the seafloor (McAlpine 2009).

Killer whales are predators of dwarf sperm whales (Dunphy-Daly et al. 2008).

3.4.2.14.5 Species-Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to dwarf sperm whales (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.15 Killer Whale (*Orcinus orca*)

A single species of killer whale is currently recognized, but strong and increasing evidence indicates the possibility of several different species of killer whales worldwide, many of which are called “ecotypes” (Ford 2008; Pilot et al. 2009; Morin et al. 2010). The different geographic forms of killer whale are distinguished by distinct social and foraging behaviors and other ecological traits (Morin et al. 2010).

3.4.2.15.1 Status and Management

The killer whale is protected under the MMPA, and the overall species is not listed pursuant to the ESA (although the southern resident population found in the Northeast Pacific is listed as endangered pursuant to the ESA and as depleted under the MMPA). Little is known of stock structure of killer whales in the North Pacific, with the exception of the northeastern Pacific where resident, transient, and offshore “ecotypes” have been described for coastal waters of Alaska, British Columbia, and Washington to California (Carretta et al. 2004). These ecotypes are defined specifically for these northeastern Pacific coastal waters, where regularly occurring populations have been studied for decades (Hoelzel and Dover 1991; Hoelzel et al. 1998). For stock assessment purposes, NMFS currently recognizes eight stocks of killer whale in the Pacific: (1) the Eastern North Pacific Alaska Resident stock; (2) the Eastern North Pacific Northern Resident stock; (3) the Eastern North Pacific Southern Resident stock; (4) the Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock; (5) the AT1 Transient stock; (6) the West Coast Transient stock; (7) the Eastern North Pacific offshore stock; and (8) the Hawaiian stock (Carretta et al. 2013). Little is known about killer whales in other tropical regions of the Pacific (Guinet and Bouvier 1995; Pitman and Ensor 2003; Forney and Wade 2006; Andrews et al. 2008). Given the lack of information, NMFS currently does not define a stock specific to the MITT Study Area.

3.4.2.15.2 Geographic Range and Distribution

Killer whales are found in all marine habitats from the coastal zone (including most bays and inshore channels) to deep oceanic basins and from equatorial regions to the polar pack ice zones of both hemispheres. Although killer whales are also found in tropical waters and the open ocean, they are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning 1999; Forney and Wade 2006). Killer whales are known to inhabit both the western and eastern temperate Pacific and likely have a continuous distribution across the North Pacific (Dahlheim et al. 2008). In most areas of their range, killer whales do not show movement patterns that would be classified as traditional migrations. However, there are often seasonal shifts in density, both onshore/offshore and north/south (Morin et al. 2010). Data from satellite telemetry showed that killer whales made seasonal, fast and direct round-trip movements to subtropical waters when foraging near the Antarctic Peninsula (Durban and Pitman 2012).

There are accounts of killer whales off the coast of Japan (Kasuya 1971). Japanese whaling and whaling sighting vessels indicate that concentrations of killer whales occurred north of the Northern Mariana Islands (Miyashita et al. 1995). Rock (1993) reported that killer whales have been reported in the tropical waters around Guam, Yap, and Palau. There are a few sightings of killer whales off Guam (Eldredge 1991), including a sighting 14.6 nm west of Tinian during January 1997 reported to the NMFS Platforms of Opportunity Program. There was also a badly decomposed killer whale found stranded on Guam in August 1981 (Kami and Hosmer 1982). On 25 May 2010, a group of approximately five killer whales, including one calf, was sighted about 20 mi. (32 km) south of FDM, apparently having just killed an unidentified large whale (Wenninger 2010).

3.4.2.15.3 Population and Abundance

There are no abundance estimates available for the killer whale in the Study Area and there were no sightings of this species during the 2007 systematic line-transect survey (Fulling et al. 2011).

3.4.2.15.4 Predator-Prey Interactions

Killer whales feed on a variety of prey, including bony fishes, elasmobranchs (a class of fish composed of sharks, skates, and rays), cephalopods, seabirds, sea turtles, and other marine mammals (Fertl et al. 1996; Jefferson et al. 2008). Some populations are known to specialize in specific types of prey (Krahn et al. 2004; Jefferson et al. 2008; Wade et al. 2009).

The killer whale has no known natural predators; it is considered to be the top predator of the oceans (Ford 2008).

3.4.2.15.5 Species-Specific Threats

Boat traffic has been shown to affect the behavior of the endangered southern resident killer whale population around San Juan Island, Washington (Williams and Ashe 2007; Lusseau et al. 2009). In the presence of boats, whales were significantly less likely to be foraging and significantly more likely to be traveling (Lusseau et al. 2009). These changes in behavior were particularly evident when boats were within 330 ft. (100 m) of the whales. While this population of killer whales is not present in the Study Area, their behavior may be indicative of other killer whale populations that are present. Additionally, there are widespread reports of killer whale interactions with fisheries including entanglement (Visser 2000; Purves et al. 2004; Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.16 False Killer Whale (*Pseudorca crassidens*)

3.4.2.16.1 Status and Management

The false killer whale is protected under the MMPA, and in the MITT Study Area is not listed pursuant to the ESA. The main Hawaiian Islands insular stock was recently listed as endangered under the ESA (National Marine Fisheries Service 2012) but this stock is considered a resident to the islands and is not likely to be present in the Study Area. Not much is known about most false killer whale populations globally. While the species is not considered rare, few areas of high density are known. For stock assessment purposes, NMFS currently recognizes five stocks of false killer whale in the Pacific: (1) the main Hawaiian Islands insular stock includes the animals that occur in waters within 100 mi. (140 km) of the main Hawaiian Islands; (2) the Northwestern Hawaiian Islands stock, which includes animals inhabiting waters within 58 mi. (93 km) of the Northwestern Hawaiian Islands and Kauai; (3) the Hawaii pelagic stock includes animals that inhabit waters greater than 25 mi. (40 km) from the main Hawaiian Islands; (4) the Palmyra Atoll stock includes whales found within the U.S. EEZ of Palmyra Atoll; and (5) the American Samoa stock, which includes false killer whales found within the U.S. EEZ of American Samoa (Carretta et al. 2013). Little is known about the stock structure of false killer whales in other regions of the world and, given the lack of information, NMFS currently does not define a stock specific to the MITT Study Area (Chivers et al. 2007).

3.4.2.16.2 Geographic Range and Distribution

The false killer whale is an oceanic species, occurring in deep waters of the Pacific (Carretta et al. 2010; Miyashita et al. 1996; Wang et al. 2001), and is known to occur close to shore near oceanic islands (Baird et al. 2012). They are found in tropical and temperate waters, generally between 50°S and 50°N latitude with a few records north of 50°N in the Pacific and the Atlantic (Odell and McClune 1999). False killer whales are not considered a migratory species, although seasonal shifts in density likely occur. Seasonal movements in the western north Pacific may be related to prey distribution (Odell and McClune 1999). Satellite-tracked individuals around the Hawaiian islands indicate that false killer whales can move extensively among different islands and also sometimes move from an island coast to as far as 60 mi. (96.6 km) offshore (Baird 2009).

During the 2007 survey of the Study Area, there were 10 false killer whale sightings in waters with bottom depths ranging from 10,095 to 26,591 ft. (3,059 to 8,058 m), and group sizes ranging from 2 to 26 individuals, with several including calves (Fulling et al. 2011). Several sightings were made over the Mariana Trench and the southeast corner of the Study Area, in waters with a bottom depth greater than 16,404 ft. (5,000 m). There was also a sighting in deep water west of the West Mariana Ridge

(Fulling et al. 2011). There is one reported false killer whale stranding which occurred in the Saipan Lagoon in 2000 (Trianni and Tenorio 2012).

3.4.2.16.3 Population and Abundance

There are estimated to be about 6,000 false killer whales in the area surrounding the Mariana Islands (Miyashita 1993). Based on sighting data from the 2007 survey, there were an estimated 637 (CV = 0.74) false killer whales in the Study Area (Fulling et al. 2011).

3.4.2.16.4 Predator-Prey Interactions

False killer whales feed primarily on deep-sea cephalopods and fish (Odell and McClune 1999). Twenty-five false killer whales that stranded off the coast of the Strait of Magellan were examined and found to feed primarily on cephalopods and fish. Squid beaks were found in nearly half of the stranded animals, and the most important prey species were found to be the squid species, *Martialiabyadesi* and *Illex argentinus,* followed by the coastal fish, *Macruronus magellanicus* (Alonso et al. 1999). Unlike other whales or dolphins, false killer whales frequently pass prey back and forth among individuals before they start to eat the fish, in what appears to be a way of affirming social bonds (Baird et al. 2010). False killer whales have been observed to attack other cetaceans, including dolphins, and large whales, such as humpback and sperm whales (Baird 2009). They are known to behave aggressively toward small cetaceans in tuna purse seine nets (National Marine Fisheries Service 2012). This species is believed to be preyed on by large sharks and killer whales (Baird 2009). Because false killer whales feed on large prey at the top of the food chain (e.g., squid, tunas) they may be impacted by competition with fisheries (Cascadia Research 2010). This species is believed to be preyed on by large sharks and killer whales (Baird 2009).

3.4.2.16.5 Species-Specific Threats

False killer whales are particularly susceptible to fishery interactions and entanglements (Baird and Gorgone 2005; Carretta et al. 2011), although there are no specific data available for this species in the Study Area. Pollutants may also pose a threat to false killer whales (Ylitalo et al. 2009). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.17 Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale is often confused with the false killer whale and melon-headed whale, which are similar in overall appearance to this species.

3.4.2.17.1 Status and Management

The pygmy killer whale is protected under the MMPA and is not listed pursuant to the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including animals found within the U.S. EEZ of the Hawaiian Islands and adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of pygmy killer whales in the MITT Study Area.

3.4.2.17.2 Geographic Range and Distribution

The pygmy killer whale has a worldwide distribution in deep tropical and subtropical oceans (Davis et al. 2000; Würsig et al. 2000). Pygmy killer whales generally do not range north of 40°N or south of 35°S (Jefferson et al. 1993), and their distribution is continuous across the Pacific (Donahue and Perryman 2008; Jefferson et al. 2008). Reported sightings suggest that this species primarily occurs in equatorial waters, at least in the eastern tropical Pacific (Perryman et al. 1994). This species has been sighted in the western Pacific (Wang and Yang 2006; Brownell et al. 2009). Most of the records outside the tropics are associated with strong, warm western boundary currents that effectively extend tropical conditions into higher latitudes (Ross and Leatherwood 1994; Baird et al. 2011; Jeyabaskaran et al. 2011).

There was only one pygmy killer whale sighting of a group of six animals during the 2007 survey of the Study Area (Fulling et al. 2011). The sighting was made near the Mariana Trench, south of Guam, where the bottom depth was 14,564 ft. (4,413 m). This is consistent with the known habitat preference of this species for deep, oceanic waters. During small boat surveys of Guam and CNMI waters in August and early September of 2011, there was a single pygmy killer whale sighting of six animals in the Marpi Reef area, northeast of Saipan, in waters with a bottom depth of 1,847 ft. (563 m) (Hill et al. 2011).

3.4.2.17.3 Population and Abundance

Although the pygmy killer whale has an extensive global distribution, it is not known to occur in high densities in any region and thus is probably one of the least abundant of the pantropical delphinids. The current best available abundance estimate for the Pacific management stock of pygmy killer whale based on a 2010 line-transect survey of the Hawaiian Islands EEZ is 3,433 individuals (CV = 0.52) (Carretta et al. 2014). Based on the single sighting during the 2007 Study Area survey, the best estimate of abundance was 78 individuals (CV = 0.88) (Fulling et al. 2011).

3.4.2.17.4 Predator-Prey Interactions

Pygmy killer whales feed predominantly on fish and squid. They have been known to attack other dolphin species, apparently as prey, although this is not common (Jefferson et al. 2008; Perryman and Foster 1980; Ross and Leatherwood 1994). The pygmy killer whale has no documented predators (Weller 2008), although it may be subject to predation by killer whales.

3.4.2.17.5 Species-Specific Threats

Pygmy killer whales may be particularly susceptible to fishery interactions and entanglements (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.18 Short-Finned Pilot Whale (*Globicephala macrorhynchus*)

3.4.2.18.1 Status and Management

The short-finned pilot whale is protected under the MMPA and is not listed pursuant to the ESA. For MMPA stock assessment reports, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete, non-contiguous areas: (1) waters off California, Oregon, and Washington; and (2) Hawaiian waters (Carretta et al. 2013). In Japanese waters, two stocks (northern and southern) have been identified based on pigmentation patterns and head shape differences of adult males (Kasuya et al. 1988). The southern stock of short-finned pilot whales is probably the stock associated with the Mariana Islands area (Kasuya et al. 1988).

3.4.2.18.2 Geographic Range and Distribution

The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world. A number of studies in different regions suggest that the distribution and seasonal inshore/offshore movements of pilot whales coincide closely with the abundance of squid, their preferred prey (Bernard and Reilly 1999; Hui 1985; Payne and Heinemann 1993). The short-finned pilot whale occurs mainly in deep offshore areas; thus, the species occupies waters over the continental shelf break, in slope waters, and in areas of high topographic relief (Olson 2009; Sakai et al. 2011). While pilot whales are typically distributed along the continental shelf break, movements over the continental shelf are commonly observed in waters off the northeastern United States (Payne and Heinemann 1993) and close to shore at oceanic islands, where the shelf is narrow and deeper waters are found nearby (Mignucci-Giannoni 1998; Gannier 2000).

Miyashita et al. (1996) reported sightings in the vicinity of the Northern Mariana Islands during February–March 1994, but did not provide the actual sighting coordinates. A group of more than 30 individuals was sighted in late April 1977 near Urunao Point, off the northwest coast of Guam (Birkeland 1977). A stranding occurred on Guam in July 1980 (Donaldson 1983; Kami and Hosmer 1982).

During the 2007 survey of the Study Area, there were a total of five sightings of short-finned pilot whales in waters with bottom depth ranging from 3,041 to 14,731 ft. (922 to 4,464 m), and group size ranging from 5 to 43 individuals (Fulling et al. 2011). Three sightings were over the West Mariana Ridge (an area of seamounts), and another sighting was 7 nm off the northeast corner of Guam, just inshore of the 9,900 ft. (3,000 m) isobath. There was also an off-effort sighting of a group of 6–10 pilot whales near the mouth of Apra Harbor (Fulling et al. 2011). No calves were seen, although there was a mixed-species aggregation involving bottlenose dolphins and rough-toothed dolphins. On 30 March 2010, during an oceanographic survey of waters in Micronesia and the CNMI, there was a single short-finned pilot whale sighting of an estimated 23 individuals, at approximately 17°N, more than 60 nm north of FDM (Oleson and Hill 2010). A mixed-species group of short-finned pilot whales and bottlenose dolphins were sighted during small boat surveys around Guam in February 2011 (HDR 2011). A group of 14 short-finned pilot whales were seen off Guam later that year (August; Hill et al. 2011). During small boat surveys in waters of the CNMI in August and September 2011, there were a total of 4 short-finned pilot whale sightings: (1) off the west coast of Guam north of Tumon Bay, (2) north of Saipan, (3) west of Tinian, and (4) off the northwest coast of Rota (Hill et al. 2011). The sighting off Rota was just inshore from the 656 ft. (200 m) isobath, while the other 3 sightings were in waters with bottom depths ranging from 1,640 to 3,281 ft. (500 to 1,000 m) (Hill et al. 2011). During small boat surveys in March 2012, a group of 23 short-finned pilot whales was sighted off the western coast of Guam (HDR EOC 2012), and several groups of 20–30 were sighted in the summer of 2012 off Guam and CNMI (Hill et al. 2013).

3.4.2.18.3 Population and Abundance

The Japanese southern stock of short-finned pilot whales has been estimated to number about 18,700 whales in the waters south of 30˚N (Miyashita 1993). There were an estimated 909 (CV = 0.68) short-finned pilot whales in the Study Area based on the 2007 survey (Fulling et al. 2011). Between 22 February 2011 and 10 June 2012, as part of an ongoing photo-identification project, a total of 5,636 photos were analyzed from 10 sightings of short-finned pilot whales in the Study Area (Hill et al. 2013). Across all locations and years, 129 individual pilot whales were identified (Hill et al. 2013).

3.4.2.18.4 Predator-Prey Interactions

Pilot whales feed primarily on squid but also take fish (Bernard and Reilly 1999). They are generally well adapted to feeding on squid (Jefferson et al. 2008; Werth 2006a). Pilot whales are not generally known to prey on other marine mammals, but records from the eastern tropical Pacific suggest that short-finned pilot whales do occasionally chase and attack, and may eat, dolphins during fishery operations (Perryman and Foster 1980; Olson 2009). They have also been observed harassing sperm whales in the Gulf of Mexico (Weller et al. 1996).

This species is not known to have any predators (Weller 2008), although it may be subject to predation by killer whales.

3.4.2.18.5 Species-Specific Threats

Short finned pilot whales are particularly susceptible to fisheries interactions and entanglement (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. This species has been a target in the drive fishery off the coast of Japan (Kasuya and Marsh 1984). Pollutants may also pose a threat to short-finned pilot whales (Tanabe et al. 1987). Pilot whales are frequently observed to strand for reasons unclear (Hohn et al. 2006). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.19 Melon-Headed Whale (*Peponocephala electra*)

3.4.2.19.1 Status and Management

The melon-headed whale is protected under the MMPA and is not listed pursuant to the ESA. For the MMPA stock assessment reports, there are two Pacific management stocks: (1) the Kohala resident stock, including melon-headed whales off the Kohala Peninsula and west coast of the island of Hawaii in less than 2,500 meters of water, and (2) the Hawaiian Islands stock, including animals found within the U.S. EEZ of the Hawaiian Islands as well as adjacent international waters (Carretta et al. 2014). Little is known about the stock structure of melon-headed whales in the MITT Study Area.

3.4.2.19.2 Geographic Range and Distribution

Melon-headed whales are found worldwide in tropical and subtropical oceanic waters. They have occasionally been reported at higher latitudes, but these movements are considered to be beyond their normal range, because records indicate these movements occurred during incursions of warm water currents (Perryman et al. 1994). Melon-headed whales are most often found in offshore deep waters but sometimes move close to shore over the continental shelf. Brownell et al. (2009) found that melon-headed whales near oceanic islands rest near shore during the day, and feed in deeper waters at night (Gannier 2002; Woodworth et al. 2012). The melon-headed whale is not known to migrate.

There was a live stranding of a melon-headed whale on the beach at Inarajan Bay, Guam in April 1980 (Donaldson 1983; Kami and Hosmer 1982), and there have been some sightings at Rota and Guam (Fulling et al. 2011; Jefferson et al. 2006). Based on sighting records, melon-headed whales are expected to occur from the shelf break (660 ft. [200 m] isobath) to seaward of the Mariana Islands area and vicinity. There is also a low or unknown occurrence from the coastline to the shelf break, since deep water is very close to shore at these islands. In July 2004, there was a sighting of an estimated 500–700 melon-headed whales and an undetermined smaller number of rough-toothed dolphins at Sasanhayan Bay (Rota) (Jefferson et al. 2006). There were two sightings of melon-headed whales during the 2007 survey of the Study Area, with group sizes of 80–109 individuals (Fulling et al. 2011). Melon-headed whales were sighted in waters with a bottom depth, ranging from 10,577 to 12,910 ft. (3,205 to 3,912 m). One of the two sightings was in the vicinity of the West Mariana Ridge. There was one sighting of approximately 53 animals on 5 February 2010, southeast of Guam during the large vessel Pacific Islands Fisheries Science Center survey (Oleson and Hill 2010). During small boat surveys in March 2012, a group of 100 melon-headed whales was sighted off the western coast of Guam in waters approximately 8,530 ft. (2,600 m) deep (HDR EOC 2012).

3.4.2.19.3 Population and Abundance

Based on sighting data from the 2007 survey, there were an estimated 2,455 (CV = 0.70) melon-headed whales in the Study Area (Fulling et al. 2011).

3.4.2.19.4 Predator-Prey Interactions

Melon-headed whales prey on squid, pelagic fishes, and occasionally crustaceans. Most of the fish and squid families eaten by this species consist of mid-water forms found in waters up to 4,920 ft. (1,500 m) deep, suggesting that feeding takes place deep in the water column (Jefferson and Barros 1997).

Melon-headed whales are believed to be preyed on by killer whales and have been observed fleeing from killer whales in Hawaiian waters (Baird et al. 2006).

3.4.2.19.5 Species-Specific Threats

Melon-headed whales are particularly susceptible to fisheries interactions and entanglement (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. Melon-headed whales have been observed to strand for reasons that are unclear (Fromm et al. 2006; Southall et al. 2006). See 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.20 Bottlenose Dolphin (*Tursiops truncatus*)

The classification of the genus *Tursiops* continues to be in question; while two species are generally recognized, the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (Rice 1998), the specific affinities of these animals remains controversial. Recent morphological analyses suggest a new species be recognized, *Tursiops australis* (Charlton-Robb et al. 2011).

3.4.2.20.1 Status and Management

The common bottlenose dolphin is protected under the MMPA and is not listed pursuant to the ESA. For the MMPA stock assessment reports, bottlenose dolphins within the Pacific U.S. EEZ are divided into seven stocks: (1) California coastal; (2) California, Oregon, and Washington Offshore; (3) Kauai and Niihau; (4) Oahu; (5) the 4-Islands Region; (6) Hawaii Island; and (7) the Hawaii Pelagic, including animals found within the U.S. EEZ of the Hawaiian Islands as well as adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of bottlenose dolphins in the MITT Study Area.

3.4.2.20.2 Geographic Range and Distribution

Common bottlenose dolphins are generally found in coastal and continental shelf waters of tropical and temperate regions of the world. They are known to occur in most enclosed or semi-enclosed seas. The species is known to inhabit shallow, murky, estuarine waters as well as deep, clear offshore waters in oceanic regions (Wells et al. 2009; Martien et al. 2012). Although in most areas bottlenose dolphins do not migrate (especially where they occur in bays, sounds, and estuaries), seasonal shifts in abundance do occur in many areas (Griffin and Griffin 2004).

Miyashita (1993) reported multiple sightings of bottlenose dolphins in the western Pacific. However, there are no stranding records available for this species in the Mariana Islands area and vicinity, and only a mention by Trianni and Kessler (2002) that bottlenose dolphins are seen in coastal waters of Guam. It is possible that bottlenose dolphins do not occur in great numbers in this island chain, but they are frequently seen. In the main Hawaiian Islands, data suggest that bottlenose dolphins exhibit site fidelity (Baird et al. 2009; Martien et al. 2012). Gannier (2002) noted that large densities of bottlenose dolphins do not occur at the Marquesas Islands and attributed this to the area's lack of a significant shelf component. A similar situation could be occurring in the Study Area and vicinity.

There were three on-effort sightings of bottlenose dolphins during the 2007 survey of the Study Area. Two of the sightings were in the vicinity of Challenger Deep, while the other sighting was east of Saipan near the Mariana Trench in deep waters ranging from 13,995 to 16,536 ft. (4,241 to 5,011 m) (Fulling et al. 2011). The Challenger Deep sighting was a mixed-species aggregation that included sperm whales (with calves) logging at the surface. Another mixed-species aggregation involved short-finned pilot whales and rough-toothed dolphins. A mixed-species group of bottlenose dolphins and short-finned pilot whales were also sighted during small boat surveys around Guam in February 2011 (HDR 2011). During small boat surveys in waters of Guam and the CNMI in August and September 2011, there were a total of 3 bottlenose dolphin sightings: (1) off Rota Bank north of Guam (14 animals including 2 calves); (2) in inshore waters off the southeast coast of Saipan (10 animals); and (3) in inshore waters off the northwest tip of Tinian (10 animals) (Hill et al. 2011). During small boat surveys in March 2012, a group of 11 bottlenose dolphins was sighted off the northwestern coast of Saipan in waters approximately 328 ft. (100 m) deep (HDR EOC 2012), and several groups observed in the summer of 2012 (Hill et al. 2013).

3.4.2.20.3 Population and Abundance

As mentioned above, little is known of the stock structure of bottlenose dolphins around the Mariana Islands. A bottlenose dolphin abundance estimate of 31,700 animals was made for the area north of the Marianas (Miyashita 1993), which may possibly represent a stock of offshore bottlenose dolphins that occurs around the Mariana Islands. In some regions "inshore" and "offshore" species differ genetically and morphologically (Tezanos-Pinto et al. 2009). Between 22 February 2011 and 29 June 2012, as part of an ongoing photo-identification project, a total of 1,793 photos were analyzed from nine sightings of bottlenose dolphins in the Study Area (Hill et al. 2013). Across all locations and years, 34 individual bottlenose dolphins were identified (Hill et al. 2013).

3.4.2.20.4 Predator-Prey Interactions

Bottlenose dolphins are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimps (Wells and Scott 1999), and using a variety of feeding strategies (Shane 1990). In addition to using echolocation, a process for locating prey by emitting sound waves that reflect back, bottlenose dolphins detect and orient fish prey by listening for the sounds their prey produce, so-called passive listening (Gannon et al. 2005). Nearshore bottlenose dolphins prey predominantly on coastal fish and cephalopods, while offshore individuals prey on open ocean cephalopods and a large variety of near-surface and mid-water fish species (Mead and Potter 1995). Pacific coast bottlenose dolphins feed primarily on surf perches (family Embiotocidae) and croakers (family Sciaenidae) (Wells and Scott 1999).

Throughout its range bottlenose dolphins are known to be preyed on by killer whales and sharks (Wells and Scott 1999; Heithaus 2001; Ferguson et al. 2012).

3.4.2.20.5 Species-Specific Threats

Common bottlenose dolphins are particularly susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.21 Pantropical Spotted Dolphin (*Stenella attenuata*)

3.4.2.21.1 Status and Management

The species is protected under the MMPA and is not listed pursuant to the ESA. Pantropical spotted dolphins may have several stocks in the western Pacific (Miyashita 1993), although this is not confirmed at present. For the MMPA stock assessment reports, four stocks of pantropical spotted dolphins are identified within waters of the Hawaiian Islands EEZ (Carretta et al. 2014). In the eastern tropical Pacific, Deoxyribonucleic acid (DNA) analyses suggest genetic isolation between inshore and offshore populations of spotted dolphins (Escorza-Treviño et al. 2005). Little is known about the stock structure of pantropical spotted dolphins in the MITT Study Area.

3.4.2.21.2 Geographic Range and Distribution

The pantropical spotted dolphin is distributed in offshore tropical and subtropical waters of the Pacific, Atlantic, and Indian Oceans between about 40°N and 40°S (Baldwin et al. 1999; Perrin 2008a), although this species is much more abundant in the lower latitudes of its range. It is found mostly in deeper offshore waters but does approach the coast in some areas (Jefferson et al. 2008; Perrin 2001). Pantropical spotted dolphins are extremely gregarious, forming groups of hundreds or even thousands of individuals. Their range in the central Pacific is from the Hawaiian Islands in the north to at least the Marquesas Islands in the south (Perrin and Hohn 1994). Based on the known habitat preferences of the pantropical spotted dolphin, this species is expected to occur seaward of the shelf break (660 ft. [200 m] isobath). Low or unknown occurrence of the pantropical spotted dolphin from the coastline to the shelf break (except in harbors and lagoons) is based on sightings of pantropical spotted dolphins being reported in coastal waters of Guam (Trianni and Kessler 2002). Although pantropical spotted dolphins do not migrate, extensive movements are known in the eastern tropical Pacific (Scott and Chivers 2009). Mixed species groups of pantropical spotted dolphins and spinner dolphins have been observed off the Waianae (western) coast of Oahu (Psarakos et al. 2003).

Pantropical spotted dolphins were sighted throughout the Study Area during the 2007 ship survey in waters with a variable bottom depth, ranging from 374 to 18,609 ft. (113 to 5,639 m) (Fulling et al. 2011). The vast majority of the sightings (65 percent; 11 of 17 sightings) were in deep waters greater than 10,000 ft. (3,030 m); these findings match the known preference of this species for oceanic waters. There was only one shallow-water sighting 1.4 nm north of Tinian, in waters with a bottom depth of 374 ft. (113 m). Pantropical spotted dolphin group size ranged from 1 to 115 individuals. There were multiple sightings that included young calves, one mixed species aggregation with melon-headed whales, and another with an unidentified *Balaenoptera* species. These pantropical spotted dolphins were identified as the offshore morphotype.

During marine mammal monitoring for Valiant Shield 07, a group of 30 pantropical spotted dolphins was observed about 140 nm southeast of Guam (Mobley 2007). A group of 17 pantropical spotted dolphins was sighted during small boat surveys around Guam in February and early March of 2010 (Ligon et al. 2011). This species was also sighted during small boat surveys in August and September of 2011, with two sightings off the northwest coast of Guam and one sighting off the northwest coast of Saipan (Hill et al. 2011). All three of these sightings were in waters with bottom depth ranging from 1,640 to 3,281 ft. (500 to 1,000 m). There were two sightings of pantropical spotted dolphins during small boat surveys in March 2012, both on 19 March off the western coast of Guam (HDR EOC 2012). The first was a group of 6 animals in waters approximately 3,940 ft. (1,200 m) deep and the second was a group of 30 animals in waters approximately 4,593 ft. (1,400 m) deep (HDR EOC 2012). Several groups of pantropical spotted dolphins were observed off Guam and the CNMI in the summer of 2012 (Hill et al. 2013).

3.4.2.21.3 Population and Abundance

There are estimated to be about 127,800 spotted dolphins in the waters surrounding the Mariana Islands (Miyashita 1993). There were an estimated 12,981 (CV = 0.70) pantropical spotted dolphins in the Study Area based on the 2007 survey data (Fulling et al. 2011). Pantropical spotted dolphins are one of the focus species of an ongoing photo-identification project in the Study Area; however, data collected to date still need to be processed for creation of photo-identification catalogs (Hill et al. 2013).

3.4.2.21.4 Predator-Prey Interactions

Pantropical spotted dolphins prey on near-surface fish, squid, and crustaceans and on some mid-water species (Perrin and Hohn 1994). Results from various tracking and food habit studies suggest that pantropical spotted dolphins in the eastern tropical Pacific and off Hawaii feed primarily at night on surface and mid-water species that rise with the deep scattering layer toward the water's surface after dark (Baird et al. 2001; Robertson and Chivers 1997).

Pantropical spotted dolphins may be preyed on by killer whales and sharks, and have been observed fleeing killer whales in Hawaiian waters (Maldini Feinholz 2003; Baird et al. 2006). Other predators may include the pygmy killer whale, false killer whale, and occasionally the short-finned pilot whale (Perrin 2008a).

3.4.2.21.5 Species-Specific Threats

Pantropical spotted dolphins located in the eastern tropical Pacific have been taken as bycatch by the tuna purse seine fishery (Wade 1994; Archer et al. 2004), and are susceptible to entanglement in fishing gear in other areas (Carretta et al. 2011). Even though direct bycatch has been reduced for these fisheries, interactions may have negative effects on species survival and reproduction (Archer et al. 2010b). There are no specific fisheries interactions or other threat data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.22 Striped Dolphin (*Stenella coeruleoalba*)

3.4.2.22.1 Status and Management

This species is protected under the MMPA and is not listed pursuant to the ESA. In the eastern Pacific, NMFS divides striped dolphin management stocks within the U.S. Pacific EEZ into two separate areas: (1) waters off California, Oregon, and Washington; and (2) waters around Hawaii, including animals found within the U.S. EEZ of the Hawaiian Islands as well as adjacent international waters (Carretta et al. 2013). In the western north Pacific, three migratory stocks are provisionally recognized (Kishiro and Kasuya 1993).

3.4.2.22.2 Geographic Range and Distribution

Striped dolphins have a cosmopolitan distribution in tropical to warm temperate waters (Perrin et al. 1994b). Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than those of any other species in the genus *Stenella* (spotted and spinner dolphins) (Baird et al. 1993). Striped dolphins are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au and Perryman 1985; Reilly 1990). This species is well documented in both the western and eastern Pacific off the coasts of Japan and North America (Perrin et al. 1994b); the northern limits are the Sea of Japan, Hokkaido, Washington state, and along roughly 40°N across the western and central Pacific (Reeves et al. 2002). In some areas, this species appears to avoid waters with sea temperatures less than 68°F (20°C) (Van Waerebeek et al. 1998).

Prior to the 2007 survey of the Study Area (Fulling et al. 2011), striped dolphins were only known from two strandings; one recorded in July 1985 (Eldredge 1991, 2003) and a second in 1993 off Saipan (Trianni and Tenorio 2012). However, striped dolphins were sighted throughout the Study Area during the 2007 survey in waters with variable bottom depth, ranging from 7,749 to 24,835 ft. (2,348 to 7,526 m) (Fulling et al. 2011). There was at least one sighting over the Mariana Trench, southeast of Saipan. Group size ranged from 7 to 44 individuals, and several sightings included calves. There were no sightings south of Guam (approximately 13°N). In early April 2010, during an oceanographic survey of waters in Micronesia and the CNMI, there were two striped dolphin sightings south of Guam, both on the 143.8 longitude line (Oleson and Hill 2010). The first sighting was of an estimated 6 animals at 11.384°N, and the second was a sighting of an estimated 12 animals at 10.286°N (Oleson and Hill 2010).

3.4.2.22.3 Population and Abundance

The population of striped dolphins south of 30˚N in the western Pacific was estimated to be around 52,600 dolphins (Miyashita 1993). Based on the 2007 survey data, there were an estimated 3,531 (CV = 0.54) striped dolphins in the Study Area (Fulling et al. 2011).

3.4.2.22.4 Predator-Prey Interactions

Striped dolphins often feed in open sea or sea bottom zones along the continental slope or just beyond it in oceanic waters. Most of their prey possess light-emitting organs, suggesting that striped dolphins may be feeding at great depths, possibly diving to 655–2,295 ft. (200–700 m) (Archer and Perrin 1999). Striped dolphins may feed at night in order to take advantage of the deep scattering layer’s diurnal vertical movements. Small mid-water fishes (in particular lanternfishes) and squids are the predominant prey (Perrin et al. 1994b; Santos et al. 2008).

This species has been documented to be preyed upon by sharks (Ross 1971; Morey et al. 2003). It may also be subject to predation by killer whales.

3.4.2.22.5 Species-Specific Threats

Striped dolphins have been taken as bycatch by the tuna purse seine fishery in the eastern tropical Pacific and are susceptible to entanglement in fishing gear in other areas (Carretta et al. 2011). There are no specific fisheries interactions or other threat data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.23 Spinner Dolphin (*Stenella longirostris*)

Four well-differentiated geographical forms of spinner dolphins have been described as separate subspecies: *Stenella longirostris* (Gray’s spinner dolphin), *Stenella longirostris orientalis* (eastern spinner dolphin), *Stenella longirostris centroamericana* (Central American spinner dolphin), and *Stenella longirostris roseiventris* (dwarf spinner dolphin). The latter three subspecies have restricted distributions and are unlikely to occur in the Study Area; hence, *Stenella longirostris* is probably the one that occurs there (Trianni and Kessler 2002; Bearzi et al. 2012; Carretta et al. 2012).

3.4.2.23.1 Status and Management

The spinner dolphin is protected under the MMPA and is not listed pursuant to the ESA. The eastern spinner dolphin (*Stenella longirostris orientalis*) is listed as depleted under the MMPA. Under the

MMPA, there are seven Pacific management stocks for Gray's spinner dolphin (*Stenella longirostris longirostris*): (1) American Samoa, (2) Hawaii Island, (3) Oahu/4-islands, (4) Kauai/Niihau, (5) Pearl and Hermes Reef, (6) Midway Atoll/Kure, and (7) Hawaii Pelagic, including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Hill et al. 2010; Carretta et al. 2013). Little is known about the stock structure of spinner dolphins in the MITT Study Area. However, based on recent sighting data (summarized in Section 3.4.2.22.2, Geographic Range and Distribution) and what is known of the Hawaiian Islands stocks, it is likely that there are both island-associated and pelagic populations of spinner dolphins in the MITT Study Area.

3.4.2.23.2 Geographic Range and Distribution

The spinner dolphin is found in tropical and subtropical waters worldwide, generally between 40°N and 40°S (Norris and Dohl 1980; Perrin and Gilpatrick 1994; Jefferson et al. 2008). Spinner dolphins occur in both oceanic and coastal environments. Most sightings of this species have been associated with inshore waters, islands, or banks (Perrin and Gilpatrick 1994). Open ocean populations, such as those in the eastern tropical Pacific, often are found in waters with a shallow thermocline (rapid temperature difference with depth) (Au and Perryman 1985; Reilly 1990; Perrin 2008b). The thermocline concentrates open sea organisms in and above it, which spinner dolphins feed on. Coastal populations are usually found in island archipelagos, where they are tied to trophic and habitat resources associated with the coast (Norris and Dohl 1980; Lammers 2004; Thorne et al. 2012).

Spinner dolphins at islands and atolls rest during daytime hours in shallow, wind-sheltered nearshore waters and forage over deep waters at night (Norris et al. 1994; Östman 1994; Gannier 2000, 2002; Benoit-Bird and Au 2003; Lammers 2004; Östman-Lind et al. 2004; Oremus et al. 2007; Benoit-Bird and Au 2009; Andrews et al. 2010;). Spinner dolphins are expected to occur in shallow water (about 164 ft. [50 m] or less) resting areas throughout the middle of the day, moving into deep waters offshore during the night to feed. Preferred resting habitat is usually more sheltered from prevailing trade winds than adjacent areas and the bottom substrate is generally dominated by large stretches of white sand bottom rather than reef and rock bottom (Norris et al. 1994; Lammers 2004). These clear, calm waters and light bottom substrates provide a less cryptic backdrop for predators like tiger sharks (Norris et al. 1994; Lammers 2004).

Spinner dolphins travel among the Mariana Islands chain (Trianni and Kessler 2002), and are expected to occur throughout the Marianas, except there have been no documented sightings within Apra Harbor. High-use areas at Guam include Bile Bay, Tumon Bay, Double Reef, north Agat Bay, and off Merizo (Cocos Lagoon area), where these animals congregate during the day to rest (Amesbury et al. 2001; Eldredge 1991). Spinner dolphins have also been seen at FDM (Trianni and Kessler 2002; Vogt 2008) and Rota (Jefferson et al. 2006). Spinner dolphins have been reported in the Saipan Lagoon at Saipan nearly every year; typically, sightings are from the northern part of the lagoon, referred to as Tanapag Lagoon (Trianni and Kessler 2002).

During the 2007 survey of the Study Area, there was one sighting of spinner dolphins northeast of Saipan in waters with a bottom depth of 1,398 ft. (424 m) (Fulling et al. 2011). Spinner dolphins have been sighted during the Navy's routine aerial surveys of FDM on several occasions, including one sighting in March of 2006, approximately 1,312 ft. (400 m) east of the island, and another sighting in July of 2007, approximately 31 mi. (50 km) north of Saipan (Vogt 2008). There were a total of 14 spinner dolphin sightings during small boat surveys around Guam (8 sightings) and Saipan (6 sightings) in February and early March of 2010 (Oleson and Hill 2010; Ligon et al. 2011). Of the eight total sightings off Guam, seven were in Agat Bay and there was a single sighting just south of Facpi Point, all inshore of the 328 ft. (100 m) isobath (Ligon et al. 2011). An additional four sightings were made in shallow (less than 328 ft. [100 m]) waters off Saipan, and another two sightings in shallow waters near Marpi Reef, northeast of Saipan (Ligon et al. 2011). During small boat surveys around the western and northern side of Guam in February 2011, there were a total of seven sightings of spinner dolphins on five different days, with group sizes ranging from 3 to 35 animals (HDR 2011). There were a total of 22 spinner dolphin sightings during small boat surveys around Guam and the CNMI in August and early September 2011 (Hill et al. 2011). All of the sightings were in waters less than 656 ft. (200 m) deep, either directly off the coasts of Guam, Saipan, Tinian, Aguijan, and Rota, or in shallow waters off Marpi Reef and Rota Bank north of Guam (Hill et al. 2011). There were five sightings of spinner dolphins during small boat surveys in March 2012, one sighting off the western coast of Guam and four sightings off Saipan (HDR EOC 2012). There were also several sightings of spinner dolphins off Guam and the CNMI during summer surveys in 2012 (Hill et al. 2013).

Given what is known of spinner dolphin resting areas in other island areas as described above, and based on both recent survey efforts and local knowledge, primary resting areas in the Study Area likely include multiple bays and inlets around Guam and the CNMI (Oleson and Hill 2010; Ligon et al. 2011; HDR EOC 2012; Hill et al. 2013). As sighting data, photographs, and biopsy samples collected during recent surveys continue to be analyzed, and as additional data are collected, it is anticipated that the identification and understanding of spinner dolphin resting areas in the Study Area will be further refined.

3.4.2.23.3 Population and Abundance

Although there are multiple sighting records of spinner dolphins around the Mariana Islands, no abundance estimate is available for the region. The only systematic line-transect survey of the Study Area was the 2007 survey for which there was only one sighting of this species (Fulling et al. 2011). Between 22 February 2011 and 16 June 2012, as part of an ongoing photo-identification project, a total of 8,047 photos were analyzed from 29 sightings of spinner dolphins in the Study Area (Hill et al. 2013). Across all locations and years, 89 individual spinner dolphins were identified (Hill et al. 2013).

3.4.2.23.4 Predator-Prey Interactions

Spinner dolphins feed primarily on small mid-water fish, squid, and shrimp, and they dive to at least 655–985 ft. (200–300 m) (Perrin and Gilpatrick 1994). Foraging can begin in the late afternoon (Lammers 2004), but takes place primarily at night when the mesopelagic prey migrates vertically towards the surface and also horizontally towards the shore (Benoit-Bird and Au 2003; Benoit-Bird 2004). Spinner dolphins track the horizontal migrations of their prey (Benoit-Bird and Au 2003), allowing for foraging efficiencies (Benoit-Bird and Au 2003; Benoit-Bird 2004). Foraging behavior has also been linked to lunar phases in scattering layers off Hawaii (Benoit-Bird and Au 2004).

Spinner dolphins may be preyed on by sharks, killer whales, pygmy killer whales, and short-finned pilot whales (Perrin 2008b).

3.4.2.23.5 Species-Specific Threats

Spinner dolphins are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011; Gerrodette and Forcada 2005; Wade et al. 2007), although there are no specific data available for this species in the Study Area. Due to their coastal distribution, spinner dolphins are also subject to potential effects from tourism (Danil et al. 2005; Timmel et al.2008). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.24 Rough-Toothed Dolphin (*Steno bredanensis*)

3.4.2.24.1 Status and Management

This species is protected under the MMPA and is not listed pursuant to the ESA. Rough-toothed dolphins are among the most widely distributed species of tropical dolphins, but little information is available regarding population status (Jefferson 2009; Jefferson et al. 2008). There are two Pacific management stocks recognized by NMFS for stock assessment purposes: (1) an American Samoa stock, and (2) a Hawaiian Islands stock including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of rough-toothed dolphins in the MITT Study Area.

3.4.2.24.2 Geographic Range and Distribution

Rough-toothed dolphins are typically found in tropical and warm temperate waters, rarely ranging north of 40°N or south of 35°S (Miyazaki and Perrin 1994). The rough-toothed dolphin is regarded as an offshore species that prefers deep water, but it can occur in waters of variable bottom depth as observed at the Windward Islands (French Polynesia) (Gannier and West 2005; Baird et al. 2008; Oremus et al. 2012). It rarely occurs close to land, except around islands with steep drop-offs nearshore (Gannier and West 2005), similar to the Study Area. In some areas, this species may be found in coastal waters and areas with shallow bottom depths (Davis et al. 1998; Fulling et al. 2011; Lodi and Hetzel 1999; Mignucci-Giannoni 1998; Ritter 2002). Rough-toothed dolphins can often be found in mixed species groups with other species such as pilot whales, bottlenose dolphins, or melon-headed whales (e.g., Fulling et al. 2011). At the Society Islands, rough-toothed dolphins were sighted in waters with bottom depths ranging from less than 330 ft. (100 m) to more than 9,845 ft. (more than 3,000 m), although they apparently favored the 1,640–4,920 ft. (500–1,500 m) range (Gannier 2000).

In July 2004, there was a sighting of an undetermined smaller number of rough-toothed dolphins mixed in with a school of an estimated 500–700 melon-headed whales at Sasanhayan Bay (Rota) in waters with a bottom depth of 249 ft. (75.9 m) (Jefferson et al. 2006). During marine mammal monitoring for Valiant Shield 07, a group of 8 rough-toothed dolphins was observed about 102 nm east of Guam (Mobley 2007). During the 2007 survey of the Study Area, there were two sightings of rough-toothed dolphins, both in groups of nine individuals with calves present in one sighting (Fulling et al. 2011). Both sightings were in deep waters, ranging from 3,343 to 14,731 ft. (1,013 to 4,464 m). One sighting was off the island of Guguan, while the other was at the southern edge of the Study Area (Fulling et al. 2011).

3.4.2.24.3 Population and Abundance

There are no abundance estimates for the rough-toothed dolphin in the western Pacific. Rough-toothed dolphins are common in tropical areas, but not nearly as abundant as some other dolphin species (Reeves et al. 2002). During the only systematic line-transect survey of the Study Area in 2007, there was only one on-effort sighting of this species (Fulling et al. 2011).

3.4.2.24.4 Predator-Prey Interactions

Prey of rough-toothed dolphins includes fish and cephalopods. They are known to feed on large fish species, such as mahi (Miyazaki and Perrin 1994; Pitman and Stinchcomb 2002). Perkins and Miller (1983) noted that parts of reef fish had been found in the stomachs of stranded rough-toothed dolphins in Hawaii. Gannier and West (2005) observed rough-toothed dolphins feeding during the day on near-surface fishes, including flying fishes.

Rough-toothed dolphins have not been documented to be preyed on by any other species, although they may be subject to predation by killer whales.

3.4.2.24.5 Species-Specific Threats

Rough-toothed dolphins are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.25 Fraser's Dolphin (*Lagenodelphis hosei*)

Since its discovery in 1956, Fraser's dolphin was known only from skeletal specimens until it was once again identified in the early 1970s (Perrin et al. 1973). Fraser's dolphin has become much better described as a species in recent years, although it is still one of the least-known species of cetaceans.

3.4.2.25.1 Status and Management

Fraser's dolphin is protected under the MMPA and is not listed pursuant to the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of Fraser's dolphin in the MITT Study Area.

3.4.2.25.2 Geographic Range and Distribution

Fraser's dolphin is a tropical oceanic species, except where deep water approaches the coast (Dolar 2008). Species found outside 30°N and 30°S are probably there due to temporary oceanographic events (Dolar 2008). In the Gulf of Mexico, this species has been seen in waters over the abyssal plain (Leatherwood et al. 1993). In the offshore eastern tropical Pacific, this species is distributed mainly in upwelling-modified waters (Au and Perryman 1985). This species has been found off the Pacific coast of Japan (Amano et al. 1996). Fraser's dolphin does not appear to be a migratory species, and little is known about its potential migrations. No specific information regarding routes, seasons, or resighting rates in specific areas is available. As noted above, data on Fraser's dolphin are lacking, and there are only a few scattered reports of stranding (Hersh and Odell 1986). They are often found with other species of cetaceans; they have been observed with melon-headed whales, sperm whales, short-finned pilot whales, false killer whales, Risso's dolphins, pantropical spotted dolphins, spinner dolphins, and striped dolphins (Jefferson and Leatherwood 1994).

3.4.2.25.3 Population and Abundance

Fraser's dolphin is not considered to be extremely abundant in any region in the world, although there is little concern regarding its global conservation status (Dolar 2008; Jefferson et al. 2008). There are no abundance estimates for Fraser's dolphin in the Study Area.

3.4.2.25.4 Predator-Prey Interactions

Fraser's dolphin feeds on mid-water fish, squid, and shrimp (Jefferson and Leatherwood 1994; Perrin et al. 1994a; Watkins et al. 1994; Mignucci-Giannoni et al. 1999).

Fraser's dolphin has been subjected to predation by killer whales (Dunn et al. 2007).

3.4.2.25.5 Species-Specific Threats

Although data on fishery-related mortality are limited, Fraser's dolphins are likely susceptible to fishery interactions (Carretta et al. 2011). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.26 Risso's Dolphin (*Grampus griseus*)

3.4.2.26.1 Status and Management

Risso's dolphin is protected under the MMPA and is not listed pursuant to the ESA. For the MMPA stock assessment reports, Risso's dolphins within the Pacific U.S. EEZ are divided into two separate areas: (1) waters off California, Oregon, and Washington; and (2) Hawaiian waters, including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of Risso's dolphins in the MITT Study Area.

3.4.2.26.2 Geographic Range and Distribution

Occurrence of this species is well known in deep open ocean waters off Hawaii, and in other locations in the Pacific (Au and Perryman 1985; Carretta et al. 2010; Leatherwood et al. 1980; Miyashita 1993; Miyashita et al. 1996; Wang et al. 2001). Several studies have documented that Risso's dolphins are found offshore, along the continental slope, and over the outer continental shelf (Green et al. 1992; Baumgartner 1997; Davis et al. 1998; Mignucci-Giannoni 1998; Kruse et al. 1999; Cañadas et al. 2002). Risso's dolphins are also found over submarine canyons (Mussi et al. 2004). Shane (1994) reported sightings of Risso's dolphins in shallow waters in the northeastern Pacific, including near oceanic islands. These sites are in areas where the continental shelf is narrow and deep water is closer to the shore (Gannier 2000, 2002).

On 30 March 2010, during an oceanographic survey of waters in Micronesia and the CNMI, there was a single Risso's dolphin sighting of three individuals, at approximately 17°N, more than 60 nm north of FDM (Oleson and Hill 2010).

3.4.2.26.3 Population and Abundance

This is a widely distributed species that occurs in all major oceans, and although no global population estimates exist, it is generally considered to be one of the most abundant of the large dolphins (Bearzi et al. 2011). Miyashita (1993) used Japanese survey data to estimate that about 7,000 Risso's dolphins occur in the area north of the Mariana Islands.

3.4.2.26.4 Predator-Prey Interactions

Cephalopods and crustaceans are the primary prey for Risso's dolphins (Clarke 1996), which feed mainly at night (Baird 2008; Jefferson et al. 2008).

This dolphin may be preyed on by both killer whales and sharks, although there are no documented reports of predation by either species (Weller 2008).

3.4.2.26.5 Species-Specific Threats

Risso's dolphins are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.27 Cuvier's Beaked Whale (*Ziphius cavirostris*)

3.4.2.27.1 Status and Management

Cuvier's beaked whale is protected under the MMPA and is not listed pursuant to the ESA. Cuvier's beaked whale stocks are defined for three separate areas within Pacific U.S. EEZ waters: (1) Alaska; (2) California, Oregon, and Washington; and (3) Hawaii, including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of Cuvier's beaked whale in the MITT Study Area (Allen et al. 2012).

3.4.2.27.2 Geographic Range and Distribution

Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres (Ferguson et al. 2006; Ferguson et al. 2005; Jefferson et al. 2008; Pitman et al. 1988). Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters. They are commonly sighted around seamounts, escarpments, and canyons (MacLeod et al. 2004). Cuvier's beaked whales are generally sighted in waters with a bottom depth greater than 655 ft. (200 m) and are frequently recorded in waters with bottom depths greater than 3,280 ft. (1,000 m) (Falcone et al. 2009; Jefferson et al. 2008). Little is known about potential migration. A study spanning 21 years off the west coast of the Island of Hawaii suggests that this species may show long-term site fidelity in certain areas (McSweeney et al. 2007).

During marine mammal monitoring for Valiant Shield 07, a single Cuvier's beaked whale was observed about 65 nm south of Guam at the edge of the Mariana Trench (Mobley 2007). One ziphiid whale was observed in deep water during the 2007 survey of the Study Area, but was not identified to the species level (Fulling et al. 2011). In August 2011, two stranded Cuvier's beaked whales were found on and near Micro Beach, Saipan (one alive and one dead); a necropsy conducted on the live stranded animal after euthanization revealed abnormalities in the animal's kidneys and intestines but further investigation is needed in order to determine if the stranding or morbidity should be categorized as natural or human-related (Saipan Tribune 2011; Hawaii Pacific University 2012). There were no Navy activities during the time of the stranding.

3.4.2.27.3 Population and Abundance

No abundance estimates for Cuvier's beaked whale are available for the Study Area.

3.4.2.27.4 Predator-Prey Interactions

Cuvier's beaked whales, similar to other beaked whale species, are apparently deepwater feeders. Stomach content analyses show that they feed mostly on deep-sea squid, fish, and crustaceans (Hickmott 2005; Baird et al. 2006; Santos et al. 2007). They apparently use suction to swallow prey (Werth 2006a, b; Jefferson et al. 2008).

Cuvier's beaked whales may be preyed upon by killer whales (Heyning and Mead 2008; Jefferson et al. 2008).

3.4.2.27.5 Species-Specific Threats

Cuvier's beaked whales commonly strand, which results in some of the occurrence data on this species, and they seem to be vulnerable to acoustic impacts (Frantzis et al. 2002; Podesta et al. 2006; Hooker et al. 2009; Southall et al. 2012a). Additionally, Cuvier's beaked whales are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.28 Blainville's Beaked Whale (*Mesoplodon densirostris*)

3.4.2.28.1 Status and Management

Blainville's beaked whale is protected under the MMPA and is not listed pursuant to the ESA. Although little is known about the stock structure of this species, based on resightings and genetic analysis of individuals around the Hawaiian Islands, NMFS recognizes a Hawaiian stock of Blainville's beaked whale, including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). However, little is known about the stock structure of Blainville's beaked whale in the MITT Study Area.

3.4.2.28.2 Geographic Range and Distribution

Blainville's beaked whales are one of the most widely distributed of the distinctive toothed whales within the *Mesoplodon* genus (MacLeod et al. 2006; Jefferson et al. 2008), and occur in temperate and tropical waters of all oceans (Jefferson et al. 1993; Jefferson et al. 2008). Blainville's beaked whales are found mostly offshore in deeper waters along the California coast, Hawaii, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific and in the eastern south Pacific (Mead 1989; Pastene et al. 1990; Leslie et al. 2005; MacLeod and Mitchell 2006;). In the eastern Pacific, where there are about a half-dozen *Mesoplodon* species known, Blainville's beaked whale is second only to the pygmy beaked whale (*Mesoplodon peruvianus*) in abundance in tropical waters (Wade and Gerrodette 1993). In waters of the western Pacific, Blainville's beaked whale is probably the most common and abundant tropical species of *Mesoplodon* (Jefferson et al. 2008). Studies suggest that some beaked whale species (Blainville's beaked whales, Cuvier's beaked whales, and northern bottlenose whales) may show long-term site fidelity in certain areas (Hooker et al. 2002; McSweeney et al. 2007).

There were two *Mesopolodon* whale sightings during the 2007 survey of the Study Area, over the West Mariana Ridge, but they were not identified to the species level (Fulling et al. 2011). During small boat surveys off Rota on 3 June 2012, two to three unidentified *Mesoplodon* whales were seen off the southwest tip of the island in 3,385 ft. (1,032 m) deep water (Hill et al. 2013).

3.4.2.28.3 Population and Abundance

There are no abundance estimates for Blainville's beaked whales in the Study Area.

3.4.2.28.4 Predator-Prey Interactions

This species preys on squid and possibly deepwater fish. Like other *Mesoplodon* species, Blainville's beaked whales apparently use suction for feeding (Werth 2006a,b; Jefferson et al. 2008; Arranz et al. 2011).

This species has not been documented to be prey to any other species, though it is likely subject to occasional killer whale predation like other whale species.

3.4.2.28.5 Species-Specific Threats

Blainville's beaked whales have been shown to react to anthropogenic noise by avoidance (Tyack et al. 2011). In response to a simulated sonar signal and pseudorandom noise (a signal of pulsed sounds that are generated in a random pattern), a tagged whale ceased foraging at depth and slowly moved away from the source while gradually ascending toward the surface (Tyack et al. 2011). Additionally, Blainville's beaked whales are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.29 Longman's Beaked Whale (*Indopacetus pacificus*)

3.4.2.29.1 Status and Management

Longman's beaked whale is protected under the MMPA and is not listed pursuant to the ESA. Longman's beaked whale is a rare beaked whale species and, until recently, was considered to be the world's rarest cetacean; the spade-toothed whale now holds that position (Dalebout et al. 2003; Pitman 2008; Thompson et al. 2012). NMFS identifies only one Pacific stock, the Hawaiian stock, which includes animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of Longman's beaked whale in the MITT Study Area.

3.4.2.29.2 Geographic Range and Distribution

Longman's beaked whale generally is found in warm tropical waters, with most sightings occurring in waters with sea surface temperatures warmer than 79°F (26°C) (Anderson et al. 2006; MacLeod et al. 2006). Longman's beaked whale is not as rare as previously thought but is not as common as the Cuvier's and *Mesoplodon* beaked whales (Ferguson and Barlow 2001). Although the full extent of this species distribution is not fully understood, there have been many recorded sightings at various locations in tropical waters of the Pacific and Indian Oceans (Afsal et al. 2009; Dalebout et al. 2002; Dalebout et al. 2003; Moore 1972). Ferguson and Barlow (2001) reported that all Longman's beaked whale sightings were south of 25°N.

Records of this species indicate presence in the eastern, central, and western Pacific, including waters off the coast of Mexico. Worldwide, Longman's beaked whales normally inhabit continental slope and deep oceanic waters (greater than 655 ft. [200 m]), and are only occasionally reported in waters over the continental shelf (Waring et al. 2001; Cañadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006; Pitman 2008). There were no sightings of Longman's beaked whale during the 2007 survey of the Study Area (Fulling et al. 2011).

3.4.2.29.3 Population and Abundance

There are no abundance estimates available for Longman's beaked whales in the Study Area.

3.4.2.29.4 Predator-Prey Interactions

Based on recent tagging data from Cuvier's and Blainville's beaked whales, Baird et al. (2005) suggested that Longman's beaked whale might feed at mid-water rather than only at or near the bottom (Heyning 1989; MacLeod et al. 2003).

This species has not been documented to be prey to any other species, although it is likely subject to occasional killer whale predation like other whale species.

3.4.2.29.5 Species-Specific Threats

In general, beaked whales may be more vulnerable to acoustic impacts (Frantzis et al. 2002; Southall et al. 2012a). Additionally, Longman's beaked whales are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. Debris ingestion could be a concern, although the volume of plastic debris found in the stomachs of two stranded Longman's beaked whales was not sufficient to be the cause of death (Yamada et al. 2012). Morbillivirus infection in a subadult male stranded in Hawaii has been confirmed (West et al. 2012). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.30 Ginkgo-Toothed Beaked Whale (*Mesoplodon ginkgodens*)

Due to the similarities between the species, the ginkgo-toothed beaked whale may be virtually indistinguishable at sea from other *Mesoplodon* species. Species identification is generally restricted to strandings as a result of a lack of obvious morphological differences between beaked whale species. Adult males can be identified by their distinctively ginkgo leaf-shaped teeth, but females and juveniles are almost impossible to identify by species (MacLeod et al. 2006; Dalebout et al. 2012; Moore and Barlow 2013). Passive acoustic monitoring has been used to distinguish beaked whale species by their echolocation calls (Baumann-Pickering et al. 2012). Visual sightings combined with the acoustic data enable researchers to characterize the whale's call (e.g., by frequency, amplitude, and duration) for subsequent use in identifying the presence of the species solely by acoustic monitoring.

3.4.2.30.1 Status and Management

The ginkgo-toothed beaked whale is protected under the MMPA and is not listed pursuant to the ESA. Due to the difficulty in distinguishing the different *Mesoplodon* species from one another, the ginkgo-toothed beaked whale has been combined with other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al. 2013). The ginkgo-toothed whale is known only from strandings in tropical waters of the Pacific and Indian Oceans (Mead 1989; Palacios and Mate 1996), and there are no occurrence records for this species in the Study Area. However, this area is within the known distribution range for this species (Taylor et al. 2008).

3.4.2.30.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit continental slope and deep ocean waters (greater than 655 ft. [200 m]) and are only occasionally reported in waters over the continental shelf (Waring et al. 2001; Cañadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006; Pitman 2008). Based on stranding records in the eastern Pacific Ocean, Palacios and Mate (1996) suggested that ginkgo-toothed beaked whales may select relatively cool, upwelling-modified habitats, such as those found in the California and Peru Currents and along the equatorial front. This species probably occurs only in the temperate and tropical waters of the Indo-Pacific; however, no specific information regarding migration is available (Jefferson et al. 2008; MacLeod and D'Amico 2006). Analysis of passive acoustic monitoring data collected off of Saipan identified calls that most likely come from ginkgo-toothed beaked whales, which are known to occur in the region from visual sightings (Baumann-Pickering et al. 2012). A species of beaked whale previously grouped with ginkgo-toothed beaked whales, *M. hotaula*, has been identified through visual observation and passive acoustic monitoring near Palmyra Atoll; however, there is no indication that this species occurs in the Study Area (Baumann-Pickering et al. 2012; Dalebout et al. 2014).

3.4.2.30.3 Population and Abundance

There are no abundance estimates available for ginkgo-toothed beaked whales in the Study Area.

3.4.2.30.4 Predator-Prey Interactions

Studies indicate that all beaked whales probably feed at or close to the bottom in deep oceanic waters, taking suitable prey opportunistically or as locally abundant, typically by suction feeding (Heyning 1989; Heyning and Mead 1996; MacLeod et al. 2003). They can dive up to 6,562 ft. (2,000 m) and spend as much as 90 minutes submerged while vocalizing underwater for navigation, prey detection, and potentially communication (Klinck et al. 2012). However feeding may also occur at mid-water rather than only at or near the bottom as shown from tagging data on Cuvier's and Blainville's beaked whales (Baird et al. 2004). This may also be the case with this species. Although no published stomach content analysis is available, ginkgo-toothed beaked whales presumably prey on squid and possibly fish, similar to other *Mesoplodon* species. These species occupy an ecological niche distinct from Cuvier's beaked whales by feeding on smaller squids, allowing the different beaked whale species to coexist (MacLeod et al. 2003; MacLeod 2005).

Ginkgo-toothed beaked whales have not been documented to be prey to any other species, although they are likely subject to occasional killer whale predation like other whale species.

3.4.2.30.5 Species-Specific Threats

In general, beaked whales may be more vulnerable to acoustic impacts (Frantzis et al. 2002; Southall et al. 2012a). Additionally, ginkgo-toothed beaked whales are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.3 Environmental Consequences

This section evaluates how and to what degree the activities described in Chapter 2 (Description of Proposed Action and Alternatives), potentially impact marine mammals known to occur within the Study Area. Tables 2.8-1 to 2.8-4 present the baseline and proposed typical training and testing activity locations for each alternative (including number of events and ordnance expended). The stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors applicable to marine mammals in the Study Area that are analyzed below include the following:

- Acoustic (sonar and other active acoustic sources; explosives; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise)
- Energy (electromagnetic devices)
- Physical Disturbance and Strike (vessels, in-water devices, military expended materials, and seafloor devices)
- Entanglement (fiber optic cables and guidance wires, and decelerators/parachutes)
- Ingestion (munitions and military expended materials other than munitions)
- Secondary (impacts associated with sediments and water quality).

In this analysis, marine mammal species are grouped together based on similar biology (such as hearing) or behaviors (such as feeding or expected reaction to stressors) when most appropriate for the discussion. In addition, for some stressors, species are grouped based on their taxonomic relationship with discussion first of mysticetes (baleen whales), followed by odontocetes (toothed whales).

When impacts are expected to be similar to all species or when it is determined there is no impact to any species, the discussion will be general and not species-specific. However, when impacts are not the same to certain species or groups of species, the discussion will be as specific as the best available data allow. In addition, if activities only occur in or will be concentrated in certain areas, the discussion will be geographically specific. Based on acoustic thresholds and criteria developed with NMFS, impacts from sound sources as stressors will be quantified at the species or stock level as is required pursuant to authorization of the proposed actions under the MMPA.

In cases where potential impacts rise to the level that warrants mitigation, mitigation measures designed to minimize the potential impacts are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). In addition to the measures presented, additional and/or different mitigations may subsequently be implemented in coordination with NMFS resulting from the MMPA authorization and ESA consultation processes.

3.4.3.1 Acoustic Stressors

3.4.3.1.1 Non-Impulse and Impulse Sound Sources

Long recognized by the scientific community (Payne and Web 1971), and summarized by the National Academies of Science, anthropogenic sound could possibly harm marine mammals or significantly interfere with their normal activities (National Research Council 2005). Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, defense, and foraging (National Research Council 2003, 2005), there are many unknowns in assessing impacts such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007). Furthermore, many other factors besides just the received level of sound may affect an animal's reaction, such as the animal's physical condition, prior experience with the sound, and proximity to the source of the sound.

As discussed in Section 3.0.4 (Acoustic and Explosives Primer) sounds may be broadly categorized as impulse or non-impulse. Impulse sounds feature a very rapid increase to high pressures, followed by a rapid return to the static pressure. Explosives and airgun detonations are examples of impulse sound sources analyzed in this document. Non-impulse sounds lack the rapid rise time and can have longer durations than impulse sounds. Non-impulse sound can be continuous or intermittent. Sonar pings, vessel noise, and underwater transponders are all examples of non-impulse sound sources analyzed in this document.

The methods used to predict acoustic effects to marine mammals build on Appendix H (Biological Resource Methods). Additional research specific to marine mammals is presented where available.

3.4.3.1.2 Analysis Background and Framework

3.4.3.1.2.1 Direct Injury

The potential for direct injury in marine mammals has been inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973; Ketten et al. 1993). Additionally, non-injurious effects on marine mammals (e.g., temporary threshold shift [TTS]) are extrapolated to injurious effects (e.g., permanent threshold shift [PTS]) based on data from terrestrial mammals to derive the criteria serving as the potential for injury (Southall et al. 2007). Actual effects on marine mammals may differ from terrestrial animals due to anatomical and physiological adaptations to the marine environment, for example, some characteristics such as a reinforced trachea and flexible thoracic cavity (Ridgway and Dailey 1972) may or may not decrease the risk of lung injury.

Potential direct injury from non-impulse sound sources, such as sonar, is unlikely due to relatively lower peak pressures and slower rise times than potentially injurious impulse sources such as explosives. Although there have been strandings associated with use of sonar, as Ketten (2012) has observed, "to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result anthropogenic sound exposures, including sonar." Non-impulse sources also lack the strong shock wave such as that associated with an explosion. Therefore, primary blast injury and barotraumas (i.e., injuries caused by large pressure changes; discussed below) would not occur due to exposure to non-impulse sources such as sonar. The theories of sonar-induced acoustic resonance and bubble formation are discussed below, although these phenomena are difficult to recreate in the natural environment under real-world conditions and are therefore unlikely to occur. The Navy has prepared a technical report presenting specific information on marine mammal stranding events that may have been associated with U.S. Navy activities (U.S. Department of the Navy 2012). The report discusses both natural and anthropogenic stimuli that may contribute to marine mammal strandings. Stranding is also discussed in Section 3.4.3.1.2.8 (Stranding) in this EIS/OEIS.

Primary Blast Injury and Barotraumas

The greatest potential for direct, non-auditory tissue effects is primary blast injury and barotraumas after exposure to high amplitude impulse sources, such as explosives. Primary blast injury refers to those injuries that result from the initial compression of a body exposed to a blast wave. Primary blast injury is usually limited to gas-containing structures (e.g., lung and gut) and the auditory system (Phillips and Richmond 1990; Craig and Hearn 1998; Craig Jr. 2001). Barotraumas refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system, as measured in terrestrial mammals, may consist of pulmonary contusions, pneumothorax, pneumomediastinum, traumatic lung cysts, or interstitial or subcutaneous emphysema (Phillips and Richmond 1990). These injuries may be fatal depending upon the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air emboli that can cause a cerebral infarct or heart attack by restricting oxygen delivery to these organs. Though often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer contusions and lacerations from blast exposure, particularly in air-containing regions of the tract. Potential traumas include hematoma, bowel perforation, mesenteric tears, and ruptures of the hollow abdominal viscera. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered.

The only known occurrence of mortality or injury to a marine mammal due to a Navy training or testing event involving impulse sources (use of underwater explosives) occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex (SSTC). This area has been used for underwater demolitions training for at least three decades without incident. On this occasion, however, a group of long-beaked common dolphins entered the mitigation zone and approximately 1 minute after detonation, three animals were observed dead at the surface; a fourth animal was discovered stranded dead approximately 42 mi. (68 km) to the north of the detonation site 3 days later. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and St. Leger 2011). See Section 3.4.3.1.2.8 (Stranding), and U.S. Department of the Navy (2012) for more information on this topic.

Auditory Trauma

Relatively little is known about auditory system trauma in marine mammals resulting from a known sound exposure. A single study spatially and temporally correlated the occurrence of auditory system trauma in humpback whales with the detonation of a 5,000 kg (11,023-pound [lb.]) explosive (Ketten et al. 1993). The exact magnitude of the exposure in this study cannot be determined, but it is likely the trauma was caused by the shock wave produced by the explosion. There are no known occurrences of direct auditory trauma in marine mammals exposed to tactical sonar or other non-impulse sound sources (Ketten 2012). The potential for auditory trauma in marine mammals exposed to impulse sources (e.g., explosives) is inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973; Ketten et al. 1993).

Acoustic Resonance

Acoustic resonance has been proposed as a hypothesis suggesting that acoustically induced vibrations (sound) from sonar or sources with similar operating characteristics could be damaging tissues of marine mammals. In 2002, NMFS convened a panel of government and private scientists to consider the hypothesis of mid-frequency sonar-induced resonance of gas-containing structures (i.e., lungs) (National Oceanic and Atmospheric Administration 2002). They modeled and evaluated the likelihood that Navy mid-frequency sonar caused resonance effects in beaked whales that eventually led to their stranding (U.S. Department of Defense 2001; U.S. Department of the Navy 2012). The conclusions of that group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding (National Oceanic and Atmospheric Administration 2002). The frequencies at which resonance was predicted to occur in uncollapsed lungs were below 50 Hz—well below the frequencies utilized by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations, even at resonant frequencies, were not considered to be of sufficient amplitude to cause tissue damage, even under the worst-case scenario in which air volumes would be undamped by surrounding tissues and the amplitude of the resonant response would be maximal. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance is not likely under realistic conditions during training and testing activities, and this type of impact is not considered further in this analysis.

Bubble Formation (Acoustically Induced)

A suggested cause of injury to marine mammals is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a bubble by exposing it to a sound field. The process is dependent upon a number of factors including the sound pressure level (SPL) and duration. Under this hypothesis, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs, (2) bubbles develop to the extent that a complement immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lung without negative consequence to the animal. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based upon what is known about the specific process involved. Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard 1979). The dive patterns of some marine mammals (e.g., beaked whales) are theoretically predicted to induce greater supersaturation (Houser et al. 2001a, b). If surface intervals between dives are short, there is insufficient time to clear nitrogen in tissues accumulated due to pressures experienced while diving. Subsequent dives can increase tissue nitrogen accumulation, leading to greater levels of nitrogen saturation at each ascent. If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness (e.g., nausea, disorientation, localized pain, breathing problems).

It is unlikely that the short duration of sonar or explosive sounds would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of the tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough period of time for bubbles to become a problematic size. Recent research with *ex vivo* supersaturated bovine tissues suggested that for a 37 kHz signal, a sound exposure level of approximately 215 dB re 1 µPa would be required before microbubbles became destabilized and grew (Crum et al. 2005). Assuming spherical spreading loss and a nominal sonar source level of 235 dB re 1 µPa, a whale would need to be within 10 yards (yd.) (10 m) of the sonar dome to be exposed to such sound levels. Furthermore, tissues in the study were supersaturated by exposing them to pressures of 400–700 kilopascals for periods of hours and then releasing them to ambient pressures. Assuming the equilibration of gases with the tissues occurred when the tissues were exposed to the high pressures, levels of supersaturation in the tissues could have been as high as 400–700 percent. These levels of tissue supersaturation are substantially higher than model predictions for marine mammals (Houser et al. 2001a, b; Saunders et al. 2008). It is improbable that this mechanism is responsible for stranding events or traumas associated with beaked whale strandings. Both the degree of supersaturation and exposure levels observed to cause microbubble destabilization are unlikely to occur, either alone or in concert (Kvadsheim et al. 2012).

There is considerable disagreement among scientists as to the likelihood of this phenomenon (Piantadosi and Thalmann 2004; Evans and Miller 2003). Although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Fernandez et al. 2005; Jepson et al. 2003), nitrogen bubble formation as the cause of the traumas has not been verified. The presence of bubbles postmortem, particularly after decompression, is not necessarily indicative of bubble pathology (Moore et al. 2009; Dennison et al. 2011; Bernaldo de Quiros et al. 2012). Prior experimental work has also demonstrated the post-mortem presence of bubbles following decompression in laboratory animals can occur as a result of invasive investigative procedures (Stock et al. 1980). Additional discussion on stranding is also provided in Section 3.4.3.1.2.8 (Stranding) in this EIS/OEIS and in U.S. Department of the Navy (2012).

3.4.3.1.2.2 Nitrogen Decompression

Although not a direct injury, variations in marine mammal diving behavior or avoidance responses could possibly result in nitrogen tissue supersaturation and nitrogen off-gassing, possibly to the point of deleterious vascular and tissue bubble formation (Jepson et al. 2003; Saunders et al. 2008; Hooker et al. 2012); nitrogen off-gassing occurring in human divers is called decompression sickness. The mechanism for bubble formation from saturated tissues would be indirect and also different from rectified diffusion, but the effects would be similar. Although hypothetical, the potential process is under debate in the scientific community (Saunders et al. 2008; Hooker et al. 2012). The hypothesis speculates that if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Jepson et al. 2003; Fernández et al. 2005; Hooker et al. 2012). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation.

Previous modeling suggested that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer and Tyack 2007). Tyack et al. (2006) suggested that emboli observed in animals exposed to mid-frequency active (MFA) sonar (Jepson et al. 2003; Fernández 2005) could stem instead from a behavioral response that involves repeated dives, shallower than the depth of lung collapse. A bottlenose dolphin was trained to repetitively dive to specific depths to elevate nitrogen saturation to the point that asymptomatic nitrogen bubble formation was predicted to occur. However, inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of any nitrogen gas bubbles (Houser et al. 2010).

More recently, modeling has suggested that the long, deep dives performed regularly by beaked whales over a lifetime could result in the saturation of long-halftime tissues (e.g., fat, bone lipid) to the point that they are supersaturated when the animals are at the surface (Hooker et al. 2009). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al. 2006; Hooker et al. 2009), while the condition of supersaturation required for bubble formation has been demonstrated in by-catch animals drowned at depth and brought to the surface (Moore et al. 2009). Since bubble formation is facilitated by compromised blood flow, it has been suggested that rapid stranding may lead to bubble formation in animals with supersaturated, long-halftime tissues because of the stress of stranding and the cardiovascular collapse that can accompany it (Houser et al. 2009). Additional discussion on stranding is also provided in Section 3.4.3.1.2.8 (Stranding) in this EIS/OEIS and in U.S. Department of the Navy (2012).

A fat embolic syndrome was identified by Fernández et al. (2005) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals and was thought to possibly arise from the formation of bubbles in fat bodies, which subsequently resulted in the release of fat emboli into the blood stream. Recently, Dennison et al. (2011) reported on investigations of dolphins stranded in 2009–2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of 22 live-stranded dolphins and in the livers of 2 of the 22 animals. The authors postulated that stranded animals are unable to recompress by diving, and thus may retain bubbles that are otherwise re-absorbed in animals that can continue to dive. The researchers concluded that the minor bubble formation observed can be tolerated since the majority of stranded dolphins released did not re-strand (Dennison et al. 2011). Recent modeling by Kvadsheim et al. (2012) determined that while behavioral and physiological responses to sonar have the potential to result in bubble formation, the actually observed behavioral responses of cetaceans to sonar did not imply any significantly increased risk over what may otherwise occur normally in individual marine mammals. As a result of these recent findings and for purposes of this analysis, the potential for acoustically mediated bubble growth and the potential for bubble formation as a result of behavioral-altered-dive profiles are not addressed further.

3.4.3.1.2.3 Hearing Loss

The most familiar effect of exposure to high intensity sound is hearing loss, meaning an increase in the hearing threshold. The meaning of the term "hearing loss" does not equate to "deafness." The phenomenon associated with hearing loss is called a noise-induced threshold shift, or simply a threshold shift (Miller 1994). If high-intensity sound over stimulates tissues in the ear, causing a threshold shift, the impacted area of the ear (associated with and limited by the sound's frequency band) no longer provides the same auditory impulses to the brain as before the exposure (Ketten 2012). The distinction between PTS and TTS is based on whether there is a complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to zero (the threshold returns to the pre-exposure value), the threshold shift is a TTS.

For temporary threshold shift, full recovery of the hearing loss (to the pre-exposure threshold) has been determined from studies of marine mammals, and this recovery occurs within minutes to hours for the small amounts of TTS that have been experimentally induced (Nachtigall et al. 2004; Finneran et al. 2010a). The recovery time is related to the exposure duration, sound exposure level, and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005; Mooney et al. 2009a, b; Finneran et al. 2010a). In some cases, threshold shifts as large as 50 dB (loss in sensitivity) have been temporary, although recovery sometimes required as much as 30 days (Ketten 2012). If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Again, for clarity, PTS, as discussed in this document, is not the loss of hearing, but instead is the loss of hearing sensitivity over a particular range of frequencies. Figure 3.4-1 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. The actual amount of threshold shift depends on the amplitude, duration, frequency, temporal pattern of the sound exposure, and on the susceptibility of the individual animal.

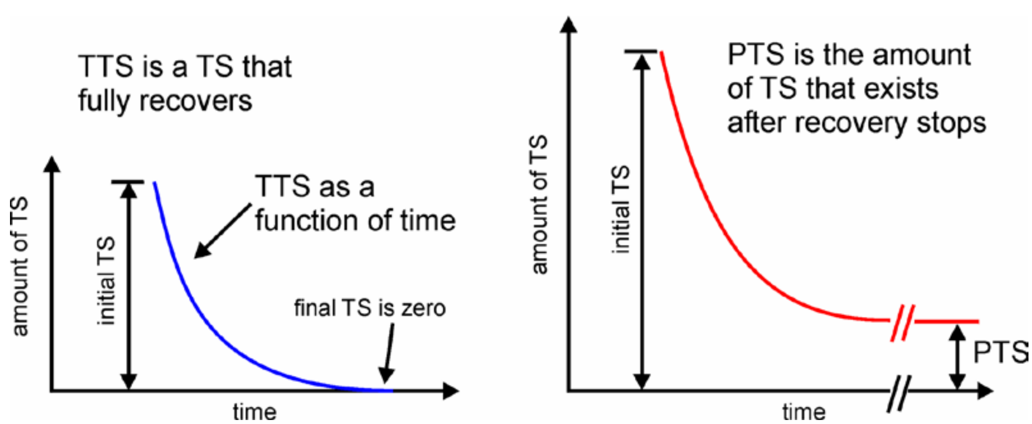

Figure 3.4-1: Two Hypothetical Threshold Shifts, Temporary and Permanent

Both auditory trauma and auditory fatigue may result in hearing loss. Many are familiar with hearing protection devices (e.g., ear plugs) required in many occupational settings where pervasive noise could otherwise cause auditory fatigue and possibly result in hearing loss. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic fatigue and exhaustion of the hair cells and cochlear tissues. Note that the term “auditory fatigue” is often used to mean “temporary threshold shift”; however, in this EIS/OEIS, a more general meaning is used to differentiate fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) from trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure).

Hearing loss, or auditory fatigue, in marine mammals has been studied extensively for many years by a number of investigators (Schlundt et al. 2000; Finneran et al. 2000, 2002, 2005, 2007, 2010a, 2010b; Nachtigall et al. 2003, 2004; Mooney et al. 2009a, 2009b; Kastak et al. 2007; Lucke et al. 2009; Ketten 2012; Kastelein et al. 2012a, 2012b, 2014a, 2014b; Finneran and Schlundt 2013; Popov et al. 2011, 2013). The studies of marine mammal auditory fatigue were all designed to determine relationships between TTS and exposure parameters such as level, duration, and frequency. In these studies, hearing thresholds were measured in trained marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds indicated the amount of TTS. Species studied include the bottlenose dolphin (total of nine individuals), beluga (two), harbor porpoise (one), finless porpoise (two), California sea lion (three), harbor seal (one), and Northern elephant seal (one). Some of the more important data obtained from these studies are onset-TTS levels—exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (for example, Schlundt et al. 2000).

The primary findings of the marine mammal TTS studies are:

- The growth and recovery of TTS are analogous to those in terrestrial mammals. This means that, as in terrestrial mammals, threshold shifts primarily depend on the amplitude, duration, frequency content, and temporal pattern of the sound exposure.
- The amount of TTS increases with sound pressure level and the exposure duration.
- For continuous sounds, exposures of equal energy lead to approximately equal effects (Ward 1997). For intermittent sounds, less hearing loss occurs than from a continuous exposure with the same energy (some recovery will occur during the quiet period between exposures) (Kryter et al. 1965, Ward 1997; Kastelein et al. 2014a). Ward (1997) studied the effects of noise on humans, and Kryter et al. (1965) analyzed research conducted on the hearing sensitivity of humans.
- Sound exposure level is correlated with the amount of TTS and is a good predictor for onset-TTS from single, continuous exposures with similar durations. This agrees with human TTS data presented by Ward et al. (1958, 1959). However, for longer duration sounds—beyond 16–32 seconds—the relationship between TTS and sound exposure level breaks down and duration becomes a more important contributor to TTS (Finneran et al. 2010a). Ward et al. (1958, 1959) conducted studies using human subjects. Finneran et al. (2010a) studied the hearing sensitivity of marine mammals (Finneran and Schlundt 2010). Still, for a wide range of exposure durations, sound exposure level correlates reasonably well to TTS growth (Popov et al. 2014).
- The maximum TTS after tonal exposures occurs one-half–one octave above the exposure frequency (Finneran et al. 2007; Schlundt et al. 2000). TTS from tonal exposures can thus extend over a large (greater than one octave) frequency range. Finneran et al. (2007) and Schlundt et al. (2000) conducted studies on marine mammals.
- For bottlenose dolphins, non-impulse sounds with frequencies above 10 kHz have a greater potential for impact than those at lower frequencies (i.e., hearing is affected at lower sound exposure levels for frequencies above 10 kHz) (Finneran et al. 2010b, Finneran and Schlundt 2013).

- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic. The amount of time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts recovery may be complete in a few minutes, while large shifts (e.g., 40 dB) require several days for recovery.
- TTS can accumulate across multiple intermittent exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same sound exposure level. This means that predictions based on total, cumulative sound exposure level (such as the predictions made in this analysis) will overestimate the amount of TTS from intermittent exposures.

Although there have been no marine mammal studies designed to measure PTS, the potential for PTS in marine mammals can be estimated based on known similarities between the inner ears of marine and terrestrial mammals. Experiments with marine mammals have revealed their similarities with terrestrial mammals with respect to features such as TTS, age-related hearing loss (called Presbycusis), ototoxic drug-induced hearing loss, masking, and frequency selectivity (Southall et al. 2007). Therefore, in the absence of marine mammal PTS data, onset-PTS exposure levels may be estimated by assuming some upper limit of TTS that equates the onset of PTS, then using TTS growth relationships from marine and terrestrial mammals to determine the exposure levels capable of producing this amount of TTS (Southall et al. 2007).

Hearing loss resulting from auditory fatigue could effectively reduce the distance over which animals can communicate, detect biologically relevant sounds such as predators, and echolocate (for odontocetes). The costs to marine mammals with TTS, or even some degree of PTS, have not been studied; however, it is likely that a relationship between the duration, magnitude, and frequency range of hearing loss could have consequences to biologically important activities (e.g., intraspecific communication, foraging, and predator detection) that affect survivability and reproduction.

3.4.3.1.2.4 Auditory Masking

As with hearing loss, auditory masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Unlike auditory fatigue, which always results in a localized stress response, behavioral changes resulting from auditory masking may or may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone.

Detections of signals under varying masking conditions have been determined for active echolocation and passive listening tasks in odontocetes (Johnson 1971; Au and Pawloski 1989; Erbe 2000; Branstetter et al 2013). These studies provide baseline information from which the probability of masking can be estimated.

Clark et al. (2009) developed a methodology for estimating masking effects on communication signals for low-frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that in Stellwagen Bank National Marine Sanctuary, when two commercial vessels pass through a North Atlantic right whale's optimal communication space (estimated as a sphere of water with a diameter of 12 mi. [20 km]), that space is decreased by 84 percent. This methodology relies on empirical data on source levels of calls (which is unknown for many species), and requires many assumptions about ancient ambient noise conditions and simplifications of animal behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Subsequent research on North Atlantic right whales at Stellwagen Bank National Marine

Sanctuary estimated that an average of 63–67 percent of their communication space has been reduced by an increase in ambient noise levels, and that noise associated with transiting vessels is a major contributor to the increase (Hatch et al. 2012).

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Changes to vocal behavior and call structure may result from a need to compensate for an increase in background noise. In cetaceans, vocalization changes have been reported from exposure to anthropogenic sources such as sonar, vessel noise, and seismic surveying (Gordon et al. 2003; Rolland et al. 2012) as well as changes in the natural acoustic environment (Dunlop et al. 2014).

In the presence of low-frequency active sonar, humpback whales have been observed to increase the length of their “songs” (Miller et al. 2000; Fristrup et al. 2003), possibly due to the overlap in frequencies between the whale song and the low-frequency active sonar. North Atlantic right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007; Rolland et al. 2012) as well as increasing the amplitude (intensity) of their calls (Parks 2009; Parks et al. 2010). In contrast, both sperm and pilot whales possibly ceased sound production during the Heard Island feasibility test (Bowles et al. 1994), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area.

Differential vocal responding in marine mammals has been documented in the presence of seismic survey sound. An overall decrease in vocalization during active surveying has been noted in large marine mammal groups (Potter et al. 2007), while detection of blue whale feeding/social calls increased when seismic exploration was underway (Di Iorio and Clark 2010), indicative of a potentially compensatory response to the increased sound level. Melcón et al. (2012) recently documented that blue whales decreased the proportion of time spent producing certain types of calls when mid-frequency sonar was present.

Evidence suggests that some marine mammals have the ability to acoustically identify potential predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required for attending to and responding to all killer whale calls. The occurrence of masking or hearing impairment provides a means by which marine mammals may be prevented from responding to the acoustic cues produced by their predators. Whether or not this is a possibility depends on the duration of the masking/hearing impairment and the likelihood of encountering a predator during the time that predator cues are impeded.

3.4.3.1.2.5 Physiological Stress

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, and interactions with predators all contribute to the stress a marine mammal experiences. In some cases, naturally occurring stressors can have profound impacts on marine mammals, resulting in physiological or behavioral responses (see next section for discussion on behavioral responses). For example, chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), has been demonstrated to result in an increased size of the adrenal glands and an increase in the number of epinephrine-producing cells (Clark et al. 2006).

Anthropogenic activities have the potential to provide additional stressors above and beyond those that occur naturally. Marine mammals may exhibit a physiological or behavioral response (or a combination of responses) upon exposure to an anthropogenic stressor (e.g., sound). If a sound is detected by a marine mammal, a stress response (e.g., startle or annoyance) or a cueing response based on a past stressful experience can occur. Although preliminary because of the small number of samples collected, different types of sounds have been shown to produce variable stress responses in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of acute stress) response to the playback of oil drilling sounds (Thomas et al. 1990) but showed an increase in catecholamines following exposure to impulse sounds produced from a seismic water gun (Romano et al. 2004). A bottlenose dolphin exposed to the same seismic water gun signals did not demonstrate a catecholamine response, but did demonstrate an elevation in aldosterone, a hormone that has been suggested as being a significant indicator of stress in odontocetes (St. Aubin and Geraci 1989; St. Aubin and Dierauf 2001). Increases in heart rate were observed in bottlenose dolphins to which conspecific calls were played, although no increase in heart rate was observed when tank noise was played back (Miksis et al. 2001). Collectively, these results suggest a variable response that depends on the characteristics of the received signal and prior experience with the received signal.

Other types of stressors include the presence of vessels, fishery interactions, acts of pursuit and capture, the act of stranding, and pollution. In contrast to the limited amount of work performed on stress responses resulting from sound exposure, a considerably larger body of work exists on stress responses associated with pursuit, capture, handling and stranding. Many cetaceans exhibit an apparent vulnerability in the face of these particular situations when taken to the extreme. One study compared pathological changes in organs/tissues of odontocetes stranded on beaches or captured in nets over a 40-year period (Cowan and Curry 2008). The type of changes observed indicate multisystemic harm caused in part by an overload of catecholamines into the system, as well as a restriction in blood supply capable of causing tissue damage and tissue death. This extreme response to a major stressor (or multiple stressors) is thought to be mediated by the overactivation of the animal's normal physiological adaptations to diving or escape.

Pursuit, capture and short-term holding of belugas have been observed to result in a decrease in thyroid hormones (St. Aubin and Geraci 1988) and increases in epinephrine (a catecholamine) (St. Aubin and Dierauf 2001). In dolphins, the duration of handling time potentially contributes to the magnitude of the stress response (St. Aubin et al. 1996; Ortiz and Worthy 2000; St. Aubin 2002). Male grey seals subjected to capture and short-term restraint showed an increase in cortisol levels accompanied by an increase in testosterone (Lidgard et al. 2008). This result may be indicative of a compensatory response that enables the seal to maintain reproduction capability in spite of stress. Elephant seals demonstrate an acute cortisol response to handling, but do not demonstrate a chronic response; on the contrary, adult females demonstrate a reduction in the adrenocortical response following repetitive chemical immobilization (Engelhard et al. 2002). Similarly, no correlation between cortisol levels and heart/respiration rate changes were seen in harbor porpoises during handling for satellite tagging (Eskesen et al. 2009). These studies illustrate the wide variations in the level of response that can occur when animals are faced with these stressors, and strongly suggest that marine mammals can acclimate to handling and perhaps other stressors.

Factors to consider when trying to predict a stress or cueing response include the mammal's life history stage and whether they are naïve or experienced with the sound. Prior experience with a stressor may be of particular importance, because repeated experience with a stressor may reduce the stress response via habituation (St. Aubin and Dierauf 2001; Bejder et al. 2009).

The sound characteristics that correlate with specific stress responses in marine mammals are poorly understood. Therefore, in practice, a stress response is assumed if a physiological reaction such as a hearing loss or trauma is predicted; or if a significant behavioral response is predicted.

3.4.3.1.2.6 Behavioral Responses

The response of a marine mammal to an anthropogenic sound will depend on the frequency, duration, and temporal pattern and amplitude of the sound, as well as the animal's prior experience with the sound. The context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure) and the animal's internal physiological state and repertoire of species-typical responses also determine the type of behavioral response that may be exhibited by the animal.

The distance from the sound source and whether it is perceived as approaching or moving away can affect the way an animal responds to a sound (Wartzok et al. 2003). For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson and others (Richardson 1995). More recent reviews (Nowacek et al. 2007; Southall et al. 2007) address studies conducted since 1995 and focus on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated.

Except for some vocalization changes that may be compensating for auditory masking, all behavioral reactions are assumed to occur due to a preceding stress or cueing response; however, stress responses cannot be predicted directly due to a lack of scientific data (see preceding section on Physiological Stress). Responses can overlap; for example, an increased respiration rate is likely to be coupled to a flight response. Differential responses between and within species are expected since hearing ranges vary across species and the behavioral ecology of individual species is unlikely to completely overlap.

Southall et al. (2007) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007). After examining all of the available data, the authors felt that the derivation of thresholds for behavioral response based solely on exposure level was not supported because context of the animal at the time of sound exposure was an important factor in estimating response. Nonetheless, in some conditions consistent avoidance reactions were noted at higher sound levels dependent on the marine mammal species or group, allowing conclusions to be drawn. Most low-frequency cetaceans (mysticetes) observed in studies usually avoided sound sources at levels of less than or equal to 160 dB re 1 µPa (Southall et al. 2007). Published studies of mid-frequency cetaceans analyzed include sperm whales, belugas, bottlenose dolphins, and river dolphins. These groups showed no clear tendency, but for non-impulse sounds, captive animals tolerated levels in excess of 170 dB re 1 µPa before showing behavioral reactions, such as avoidance, erratic swimming, and attacking the test apparatus. High-frequency cetaceans (observed from studies with harbor porpoises) exhibited changes in respiration and avoidance behavior at levels between 90 and 140 dB re 1 µPa, with profound avoidance behavior noted for levels exceeding this. Recent studies with beaked whales have shown them to be particularly sensitive to noise, with animals during three playbacks of sound breaking off foraging dives at levels below 142 dB re 1 µPa, although acoustic monitoring during actual sonar exercises revealed some beaked whales continuing to forage at levels up to 157 dB re 1 µPa (Tyack et al. 2011). Passive acoustic monitoring of beaked whales, classified as Blainville's beaked whales and Cross-seamount type beaked whales, at the Pacific Missile Rage Facility (PMRF) showed statistically significant differences in dive rates, diel occurrence patterns, and spatial distribution of dives after the initiation of a training event. However, for the beaked whale dives that continued to occur during mid-frequency active sonar (MFAS) activity, differences from normal dive profiles and click rates were not detected with estimated received levels up to 137 decibels references to 1 micropascal (dB re 1 µPa) while the animals were at depth during their dives (Manzano-Roth et al. 2013).

Behavioral Responses to Impulse Sound Sources

Mysticetes

Baleen whales have shown a variety of responses to impulse sound sources (e.g., explosives), including avoidance, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Southall et al. 2007; Richardson 1995; Gordon et al. 2003). While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson 1995), some whales avoided vessels by more than 20 km at received levels as low as 120 dB re 1 µPa root mean square (rms). Additionally, Malme et al. (1988) observed clear changes in diving and respiration patterns in bowheads at ranges up to 39 nm from seismic vessels, with received levels as low as 125 dB re 1 µPa. Behavioral responses in bowheads in the presence of seismic surveys has been shown to be varied and dependent on a number of other factors influencing behavior, including the activity the whale is engaged in at the time (e.g., foraging, traveling, socializing), season, and whether or not calves are present during the exposure (Robertson et al. 2013).

Humpback whales showed avoidance behavior at ranges of 3–5 nm from a seismic array during observational studies and controlled exposure experiments in western Australia (McCauley 1998). Todd et al. (1996) found no clear short-term behavioral responses by foraging humpbacks to explosions associated with construction operations in Newfoundland, but did see a trend of increased rates of net entanglement and a shift to a higher incidence of net entanglement closer to the noise source. Seismic airgun surveys conducted off of the Angolan coast over a 10-month period did not significantly reduce sightings of humpback whales in the area. Furthermore, the distance from the ship to observed humpbacks was not significantly different when the airgun was in use compared to when it was not in use (Weir 2008). Some humpbacks were observed approaching the survey vessel while the airgun was in use. This suggests that the low-frequency, impulse sounds may be mistaken by male humpbacks for breaches, tail flips, and other similar sounds produced by competitors during the breeding season.

Gray whales migrating along the U.S. west coast showed avoidance responses to seismic vessels by 10 percent of animals at 164 dB re 1 µPa, and by 90 percent of animals at 190 dB re 1 µPa, with similar results for whales in the Bering Sea (Malme et al. 1986, 1988). In contrast, sound from seismic surveys was not found to impact feeding behavior or exhalation rates while resting or diving in western gray whales off the coast of Russia (Yazvenko et al. 2007; Gailey et al. 2007).

Seismic pulses at average received levels of 131 dB re 1 micropascal squared second (μPa^2-s) caused blue whales to increase call production (Di Iorio and Clark 2010). In contrast, McDonald et al. (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 5 nm from the seismic vessel (estimated received level 143 dB re 1 µPa peak-to-peak). These studies demonstrate that even low levels of sound received far from the sound source can induce behavioral responses.

Odontocetes

Madsen et al. (2006) and Miller et al. (2009a) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys in a controlled experiment. Sound sources were from approximately 2–7 nm away from the whales, and based on multipath propagation; received levels were as high as 162 dB SPL re 1 µPa with energy content greatest between 0.3 and 3.0 kHz (Madsen et al. 2006). The whales showed no horizontal avoidance, although the whale that was approached most closely had an extended resting period and did not resume foraging until the airguns had ceased firing (Miller et al. 2009). The remaining whales continued to execute foraging dives throughout exposure; however, swimming movements during foraging dives were 6 percent lower during exposure than control periods, suggesting subtle effects of sound on foraging behavior (Miller et al. 2009).

Weir (2008) observed that seismic airgun surveys along the Angolan coast did not significantly reduce the encounter rate of sperm whales during the 10-month survey period. Neither were avoidance behaviors to airgun impulse sounds observed in sperm whales. Thompson et al. (2013) showed that seismic surveys conducted over a 10 day period in the North Sea did not result in the broad-scale displacement of harbor porpoises away from preferred habitat. The harbor porpoises were observed to leave the area at the onset of survey, but returned within a few hours, and the overall response of the porpoises decreased over the 10 day period. However, Atlantic spotted dolphins did show a significant, short-term avoidance response to airgun impulses. The dolphins were observed at greater distances from the vessel when the airgun was in use, and when the airgun was not in use they readily approached the vessel to bow ride.

Captive bottlenose dolphins sometimes vocalized after an exposure to impulse sound from a seismic water gun (Finneran et al. 2002, Finneran and Schlundt 2010).

Behavioral Responses to Sonar and other Active Acoustic Sources

Mysticetes

Mysticetes have shown a variety of behavioral reactions to non-impulse sound sources (e.g., sonar). Specific to U.S. Navy systems using low-frequency sound, studies were undertaken in 1997–98 pursuant to the Navy's Low-frequency Sound Scientific Research Program. These studies found only short-term responses to low-frequency sound by mysticetes (fin, blue, and humpback) including changes in vocal activity and avoidance of the source vessel (Clark and Fristrup 2001; Miller et al. 2000; Croll et al. 2001; Fristrup et al. 2003; Nowacek et al. 2007). Baleen whales exposed to moderate low-frequency signals demonstrated no variation in foraging activity (Clark and Fristrup 2001; Croll et al. 2001). However, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives. The alarm signal was long, lasting several minutes, and was designed to elicit a reaction from the animals as part of a prospective tool that could be used to protect the whales from ship strikes (Nowacek et al. 2004a). Although the animal's received sound pressure level was similar in the latter two studies (133–150 dB re 1 µPa), the frequency, duration, and temporal pattern of signal presentation were different. Additionally, the right whales did not respond to playbacks of either right whale social sounds or vessel noise, highlighting the importance of the sound characteristics, species differences, and individual sensitivity in producing a behavioral reaction.

As part of the Acoustic Thermometry of Ocean Climate program, two low-frequency, underwater sound sources were deployed in phases in deepwater locations off California and Hawaii to study large-scale changes in ocean temperature and the effects of low-frequency transmissions on marine mammals. The acoustic transmissions were detected at multiple locations in the Pacific Ocean, often thousands of kilometers from the sound source. The low-frequency signals from the sound sources were not found to affect dive times of humpback whales in Hawaiian waters, (Frankel and Clark 2000). Frankel and Clark (2000) reported that while no overt behavioral responses were noted, the distance and time between successive surfacings of humpbacks increased slightly with an increase in estimated received sound level. Although the change in surfacing behavior was minor, multiple years of data from different locations and using a similar sound source show that the behavior is repeatable. Subtle effects were also observed in elephant seal dives that varied in direction and degree among the individual seals, again illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low-frequency calls usually associated with feeding behavior (Melcón et al. 2012). It is not known whether the lower rates of calling actually indicated a reduction in feeding behavior or social contact since the study used data from remotely deployed, passive acoustic monitoring buoys. In contrast, blue whales increased their likelihood of calling when ship noise was present, and decreased their likelihood of calling in the presence of explosive noise, although this last result was not statistically significant, possibly due to the low sample size (Melcón et al. 2012). Additionally, the likelihood of an animal calling decreased with the increased received level of mid-frequency sonar, beginning at a sound pressure level of approximately 110–120 dB re 1 µPa (Melcón et al. 2012). Blue whales responded to a simulated mid-frequency sound source at received sound levels up to 160 dB re 1 µPa, by exhibiting generalized avoidance responses and changes to dive behavior during controlled exposure experiments (CCEs) (Goldbogen et al. 2013). However, reactions were not consistent across individuals based on received sound levels alone, and likely were the result of a complex interaction between sound exposure factors such as proximity to sound source and sound type (mid-frequency sonar simulation vs. pseudo-random noise), environmental conditions, and behavioral state. Surface feeding whales did not show a change in behavior during CCEs, but deep feeding and non-feeding whales showed temporary reactions that quickly abated after sound exposure. Whales were sometimes less than a mile from the sound source during the controlled exposure experiments. Furthermore, the more dramatic reactions reported by Goldbogen et al. (2013) were from non-sonar like signals, a pseudorandom noise that could likely have been a novel signal to blue whales.

In a behavioral response study conducted in Australian waters, humpback whales responded to an artificial tone by moving away from the stimulus and surfacing more often, presumably to avoid the stimulus (Dunlop et al. 2013b). The response to the tone was consistent and was dependent on received level and distance from the source. When a conspecific social sound was used as the stimulus, the response of the whales was inconsistent and depended on the social makeup of the group at the time of the stimulus. In some cases the whales approached the vessel (sound source), and, as with the tone stimulus, changes in diving and surfacing behavior were noted.

Preliminary results from the 2010 to 2011 field season of an ongoing behavioral response study in Southern California waters indicated that in some cases and at low RLs, tagged blue whales responded to mid-frequency sonar but that those responses were mild and there was a quick return to their baseline activity (Southall et al. 2012b). These preliminary findings from Melcón et al. (2012) and Goldbogen et al. 2013 are consistent with the Navy's criteria and thresholds for predicting behavioral effects to mysticetes from sonar and other active acoustic sources used in the quantitative acoustic effects analysis (see Section 3.4.3.1.2.6, Behavioral Responses). The behavioral response function predicts a probability of a substantive behavioral reaction for individuals exposed to a received sound pressure level of 120 dB re 1 µPa or greater, with an increasing probability of reaction with increased received level as demonstrated in Melcón et al. (2012). Although the long-term implications of disruption in call production to blue whale foraging and other behaviors are currently not well understood, vessel noise is much more pervasive in both time and space compared to the intermittent use of various types of sonar, including fathometers, fish-finders, research sonar, and Navy mid-frequency sonar. Understanding the impacts of vessel noise on blue whale call production is likely more of a concern given its broader implications. Further discussion of impacts from vessel noise is presented in the section "Behavioral Responses to Vessels."

Odontocetes

From 2007 to the present, behavioral response studies were conducted through the collaboration of various research organizations in the Bahamas, Southern California, the Mediterranean, Cape Hatteras, and Norwegian waters (DeRuiter et al. 2013b; Miller et al. 2011). These studies attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to better understand their potential impacts. Results from the 2007 to 2008 study conducted near the Bahamas showed a change in diving behavior of an adult Blainville's beaked whale to playback of mid-frequency source and predator sounds (Boyd et al. 2008; Tyack et al. 2011). Reaction to mid-frequency sounds included premature cessation of clicking and termination of a foraging dive, and a slower ascent rate to the surface.

Preliminary results from the behavioral response studies in Southern California waters have been presented for multiple field seasons (Southall et al. 2011, 2012a, 2013, 2014). Stimpert et al. (2014) tagged a Baird's beaked whale, which was subsequently exposed to simulated mid-frequency sonar. Changes in the animal's dive behavior and locomotion were observed when received level reached 127 dB re 1µPa. DeRuiter et al. (2013a) presented results from two Cuvier's beaked whales that were tagged and exposed to simulated MFA sonar during the 2010 and 2011 field seasons of the Southern California behavioral response study. The 2011 whale was also incidentally exposed to MFA sonar from a distant naval exercise. Received levels from the MFA sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa rms, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure to distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Cuvier's beaked whale responses suggested particular sensitivity to sound exposure as consistent with results for Blainville's beaked whale. Passive acoustic monitoring of a British major exercise in 2006 on an instrumented range reported that beaked whale vocalizations occurred less frequently in the vicinity of the exercise and as the exercise progressed, and that vocalizations were ultimately not detected at all in the vicinity of the training activity. However, higher concentrations of vocalizations were detected at the range boundaries, suggesting that the beaked whales may have moved to the periphery of the range to forage (Defence Science and Technology Laboratory 2007). It is possible, however, that the whales may have remained at the center of the range near the exercise and simply stopped vocalizing.

Controlled exposure experiments in 2007 and 2008 in the Bahamas recorded responses of false killer whales, short-finned pilot whales, and melon-headed whales to simulated MFA sonar (DeRuiter et al. 2013b). The responses to exposures between species were variable and are indicative of variability in species sensitivity. After hearing each MFA signal, false killer whales were found to have "increase[d] their whistle production rate and made more-MFA-like whistles" (DeRuiter et al. 2013b). In contrast, melon-headed whales had "minor transient silencing" after each MFA signal, while pilot whales had no apparent response. Consistent with the findings of other previous research (see Southall et al. 2007 for review), DeRuiter et al. (2013b) found the responses were variable by species and with the context of the sound exposure. In the 2007–2008 Bahamas study, playback sounds of a potential predator—a killer whale—resulted in a similar but more pronounced reaction, which included longer inter-dive intervals and a sustained straight-line departure of more than 20 km from the area. The authors noted, however, that the magnified reaction to the predator sounds could represent a cumulative effect of exposure to the two sound types since killer whale playback began approximately 2 hours after playback of the mid-frequency source. In contrast, preliminary analyses suggest that none of the pilot whales or false killer whales in the Bahamas showed an avoidance response to controlled exposure playbacks (Southall et al. 2009b).

Miller et al. (2011) reported on behavioral responses of pilot whales, killer whales, and sperm whales off Norway to a Norwegian Navy sonar (Sea Mammals, Sonar, and Safety Project [hereafter referred to as the 3S study]) (see also Miller et al. 2012, Sivle et al. 2012, Kuningas et al. 2013, Antunes et al. 2014, Miller et al. 2014). The sonar outputs included 1 to 2 kHz up- and down-sweeps and 6-7 kHz upsweeps; source levels were ramped-up from 152to 158 dB re 1 µPa @ 1m to a maximum of 195-214 dB re 1 µPa @ 1m. Reactions at different distances and received levels were variable, and types of responses observed included cessation of feeding, avoidance, changes in vocalizations, and changes in dive behavior. Some exposures elicited no observable reactions, and others resulted in brief or minor reactions, such as minor changes in vocalizations or locomotion. The experimental exposures occurred across different behavioral and environmental contexts, which may have played a role in the type of response observed, at least for killer whales (see Miller et al. 2014).

Many aspects of the experiment differ from typical Navy actions and may have exacerbated observed reactions; for example, animals were directly approached by the source vessel, researchers conducted multiple approaches toward the same animal groups, some exposures were conducted in bathymetrically restricted areas, and, in some cases, researchers "leapfrogged" the groups to move ahead of the animals on their travel path. Many of the observed behavioral responses were of a prolonged duration, as the animals continued moving to avoid the oncoming vessel as it corrected course toward the animals. At the onset of each sonar exposure session, the signal amplitude was ramped-up over several pings while the vessel approached the animals. This rapid increase in received levels of subsequent sonar pings during ramp-up could have been perceived by the animals as a rapidly approaching source. In contrast, U.S. Navy vessels avoid approaching marine mammals head-on, and vessels will maneuver to maintain a distance of at least 500 yd. (457 m) from observed animals. Furthermore, Navy mitigation measures would dictate power-down of hull-mounted ASW sonars within 1,000 yd. (914 m) of marine mammals and ultimately shutdown if an animal is within 200 yd. (183 m).

Two of the four exposed killer whale groups were foraging prior to the initial sonar exposure; they ceased to feed and began avoiding the vessel during the first exposure session. Received sound pressure levels corresponding to avoidance reactions or changes in behavioral state varied from approximately 94 dB re 1 µPa at 8.9 km to 164 dB re 1 µPa at 3,500 yd. (3.2 km). One killer whale group that was not foraging was in a shallow part of the fjord and could only be approached to within about 1,750 yd. (1.6 km) by the vessel towing the sonar source. Received sound pressure levels in that case were as high as 166 dB re 1 µPa with no observed reactions. This group did not respond to any of the exposures until the final approach, when the group had moved out of the shallow part of the fjord and a young calf became separated from the rest of the group.

Pilot whale behavioral responses occurred at received sound pressure levels between approximately 152 to 175 dB re 1 µPa corresponding to distances of 3,400 yd. (3.1 km) to 98 yd. (90 m), respectively;

although during exposures as high as approximately 172 dB re 1 µPa corresponding to a distance of 380 yd. (350 m), no more than minor and brief reactions were observed.

Sperm whales responded at received levels between 116 to 156 dB re 1 µPa, corresponding to distances of around 2,000 yd. (1.8 km) to 9,800 yd. (9.0 km), respectively. However, sperm whales exposed to higher levels (up to 166 dB re 1 µPa at 980 yd. [0.9 km]) showed no response, or no more than a brief and minor response. These counterintuitive results with respect to received sound pressure level demonstrate some of the issues that must be addressed when interpreting behavioral response data for marine mammals in different contextual conditions.

The 3S study included some control passes of ships with the sonar off to discern the behavioral responses of the animals to vessel presence alone versus active sonar. A single control pass was conducted on killer whales, which was insufficient to rule out vessel presence as a factor in behavioral response. During four control passes on pilot whales, Miller et al. (2011) described similar responses for two of the groups to those observed when the vessels approached with active sonar. In some cases, it is difficult to ascertain if the received sound pressure level alone caused the reactions, or whether the repeated, close passes of the research vessel contributed to the observed behavioral reactions.

Through analysis of the behavioral response studies, a preliminary overarching effect of greater sensitivity to all anthropogenic exposures was seen in beaked whales compared to the other odontocetes studied (Southall et al. 2009a). Therefore, more recent studies have focused specifically on beaked whale responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge 2006; Defence Science and Technology Laboratory 2007; Claridge and Durban 2009; Moretti et al. 2009; McCarthy et al. 2011; Tyack et al. 2011). In the Bahamas, Blainville's beaked whales located on the range will move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge and Durban 2009; Moretti et al. 2009; McCarthy et al. 2011; Tyack et al. 2011). Moretti et al. (2014) used recordings from seafloor-mounted hydrophones at the Atlantic Undersea Test and Evaluation Center (AUTEC) to analyze the probability of Blainsville's beaked whale dives before, during, and after Navy sonar exercises.

In May 2003, killer whales in Haro Strait, Washington, were observed exhibiting what were believed by some observers to be abnormal behaviors while *USS SHOUP* (DDG-86) was in the vicinity and engaged in MFA sonar operations. Observed behaviors included bunching nearshore and other behaviors consistent with avoidance (National Marine Fisheries Service 2005). However, other experienced scientists interpreted the behaviors as within the normal range of behaviors for killer whales. Sound fields modeled for the *USS SHOUP* transmissions (National Marine Fisheries Service 2005; U.S. Department of the Navy 2003; Fromm 2004a, 2004b) estimated a mean received sound pressure level of approximately 169.3 dB re 1 µPa at the location of the killer whales during the closest point of approach between the animals and the vessel (estimated sound pressure levels ranged from 150 to 180 dB re 1 µPa). Response behaviors including avoidance behaviors were also observed from Dall's porpoise and a minke whale in the area.

In the Caribbean, research on sperm whales near the Grenadines in 1983 coincided with the U.S. intervention in Grenada, where sperm whales were observed to interrupt their activities by stopping echolocation and leaving the area in the presence of underwater sounds surmised to have originated from submarine sonar signals since the source was not visible (Watkins and Schevill 1975; Watkins et al. 1985). The authors did not provide any sound levels associated with these observations, although they did note getting a similar reaction from banging on their boat hull. It was unclear if the sperm whales were reacting to the "sonar" signal itself or to a potentially new unknown sound in general, as had been demonstrated previously on another occasion in which sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins and Schevill 1975).

Researchers at the Navy's Marine Mammal Program facility in San Diego, California, have conducted a series of controlled experiments on bottlenose dolphins and beluga whales to study TTS (Schlundt et al. 2000; Finneran et al. 2001; Finneran et al. 2003; Finneran and Schlundt 2004; Finneran et al. 2005). Ancillary to the TTS studies, scientists evaluated whether the marine mammals performed their trained tasks when prompted, during and after exposure to mid-frequency tones. Altered behavior during experimental trials usually involved refusal of animals to return to the site of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Schlundt et al. 2000; Finneran et al. 2002). Bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178–193 dB re 1 μPa rms, and beluga whales did so at received levels of 180–196 dB re 1 μPa and above. In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000). While these studies were generally not designed to test avoidance behavior and animals were commonly reinforced with food, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to sound sources. More recently, a controlled-exposure study was conducted with U.S. Navy bottlenose dolphins at the Navy Marine Mammal Program facility specifically to study behavioral reactions to simulated mid-frequency sonar (Houser et al. 2013). Animals were trained to swim across a pen, touch a panel, and return to the starting location. During transit, a simulated mid-frequency sonar signal was played. Behavioral reactions were more likely with increasing received level and included increased respiration rates, fluke or pectoral fin slapping, and refusal to participate, among others. From these data, it was determined that bottlenose dolphins were more likely to respond to the initial trials, but habituated to the sound over the course of 10 trials except at the highest received levels. All dolphins responded at the highest received level (185 dB re 1 μPa).

These observations are particularly relevant to situations where animals are motivated to remain in an area where they are being exposed to sound.

Studies with captive harbor porpoises showed increased respiration rates upon introduction of acoustic alarms, such as those used on fishing nets to help deter marine mammals from becoming caught or entangled (Kastelein et al. 2001; Kastelein et al. 2006) and emissions for underwater data transmission (Kastelein et al. 2005). However, exposure of the same acoustic alarm to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006; Lucke et al. 2009), again highlighting the importance in understanding species differences in the tolerance of underwater noise (Southall et al. 2007, Henderson et al. 2014).

Behavioral Responses to Vessels

Sound emitted from large vessels, such as shipping and cruise ships, is the principal source of low-frequency noise in the ocean today, and marine mammals are known to react to or be affected by that noise (Richardson et al. 1995; Foote et al. 2004; Hildebrand 2005; Hatch and Wright 2007; Holt et al. 2008; Melcón et al. 2012).

In short-term studies, researchers have noted changes in resting and surface behavior states of cetaceans to whale watching vessels. A number of studies investigating the potential effects of whale watching and vessel traffic on cetaceans have been conducted (Acevedo 1991; Aguilar de Soto et al. 2006; Arcangeli and Crosti 2009; Au and Green 2000; Erbe 2002; Williams et al. 2009; Noren et al. 2009; Stensland and Berggren 2007; Stockin et al. 2008, Christiansen et al. 2010).

A brief summary is presented in this EIS/OEIS; however the topic is too extensive to be covered adequately in this EIS/OEIS. Most studies associated with whale watching are opportunistic and have only ascertained the short-term response to vessel sound and vessel traffic (May-Collado and Quiñones-Lebrón 2014, Lusseau 2006; Magalhães et al. 2002; Richardson et al. 1995; Watkins 1981); however, recent research has attempted to quantify the effects of whale watching using focused experiments (Pirotta et al. 2015, Meissner et al. 2015). The long-term and cumulative implications of ship sound on marine mammals is largely unknown (National Marine Fisheries Service 2007). Clark et al. (2009) provided a discussion on calculating the cumulative impacts of anthropogenic noise on baleen whales and estimated that in one Atlantic setting and with the noise from the passage of two vessels, the optimal communication space for North Atlantic right whales could be decreased by 84 percent.

Christensen et al. (2013) observed minke whales on feeding grounds frequented by whale watching vessels and compared behavior (e.g., breathing interval), in the presence and absence of the vessels. The authors observed that the presence of whale watching vessels disturbed the feeding behavior of the minke whales, which they hypothesize could have long-term consequences for the population by reducing the energy needed for fetal development and the survival of calves.

Ellison et al. (2012) outlined an approach to assessing the effects of sound on marine mammals that incorporates contextual-based factors. They recommend considering not just the received level of sound, but also the activity the animal is engaged in at the time the sound is received, the nature and novelty of the sound (is this a new sound from the animal's perspective), and the distance between the sound source and the animal. They submit that this "exposure context," as described, greatly influences the type of behavioral response exhibited by the animal.

Bassett et al. (2012) recorded vessel traffic over a period of approximately 1 year (short by 11 percent) as large vessels passed within 11 nm of a hydrophone site located at Admiralty Inlet in Puget Sound, Washington. Although not specifically relevant to the Study Area, the research provides insight into noise generated by transiting vessels, including military vessels. During this period there were 1,363 unique Automatic Identification System transmitting vessels recorded. Given they are much fewer in number, Navy vessels were a small component of overall vessel traffic and vessel noise in most areas where they operated. Mintz and Filadelfo (2011) provide a general summary and comparison of the effects of military and non-military vessel noise in the U.S. EEZ. In addition, Navy and U.S. Coast Guard combatant vessels have been designed to generate minimal noise and use ship-quieting technology to elude detection by enemy passive acoustic devices (Southall et al. 2005; Mintz and Filadelfo 2011).

Mysticetes

Fin whales may alter their swimming patterns by increasing speed and heading away from the vessel, as well as changing their breathing patterns in response to a vessel approach (Jahoda et al. 2003). Vessels that remained 328 ft. (100 m) or farther from fin and humpback whales were largely ignored in one study in an area where whale watching activities are common (Watkins 1981). Only when vessels approached more closely did the fin whales in this study alter their behavior by increasing time at the surface and exhibiting avoidance behaviors. Other studies have shown when vessels are near, some but not all fin whales change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au and Green 2000; Richter et al. 2003; Williams et al. 2002).

Based on passive acoustic recordings and in the presence of sounds from passing vessels, Melcón et al. (2012) reported that blue whales had an increased likelihood of producing certain types of calls. At present it is not known if these changes in vocal behavior corresponded to changes in foraging or any other behaviors.

In the Watkins (1981) study, humpback whales did not exhibit any avoidance behavior but did react to vessel presence. In a study of regional vessel traffic, Baker et al. (1983) found that when vessels were in the area, the respiration patterns of the humpback whales changed. The whales also exhibited two forms of behavioral avoidance: horizontal avoidance (changing direction or speed) when vessels were between 1.24 and 2.48 mi. (2,000 and 4,000 m) away, and vertical avoidance (increased dive times and change in diving pattern) when vessels were between 0 and 1.24 mi. (2,000 m) away (Baker et al. 1983). Similar findings were documented for humpback whales when approached by whale-watch vessels in Hawaii, with responses including increased speed, changed direction to avoid, and staying submerged for longer periods of time (Au and Green 2000).

Gende et al. (2011) reported on observations of humpback whale in inland waters of southeast Alaska subjected to frequent cruise ship transits (i.e., in excess of 400 transits in a 4-month season in 2009). The study was focused on determining if close encounter distance was a function of vessel speed. The reported observations, however, seem in conflict with other reports of avoidance at much greater distance so it may be that humpback whales in those waters are more tolerant of vessels (given their frequency) or are engaged in behaviors, such as feeding, that they are less willing to abandon. This example again highlights that context is critical for predicting and understanding behavioral reactions as concluded by Southall et al. (2007). Navy vessels avoid approaching large whales head on and maneuver to maintain a mitigation zone of 500 yd. (460 m) around observed marine mammals.

Sei whales have been observed ignoring the presence of vessels and passing close to the vessel (National Marine Fisheries Service 1998). In the presence of approaching vessels, blue whales perform shallower dives accompanied by more frequent surfacing, but otherwise do not exhibit strong reactions (Calambokidis et al. 2009a). Minke whales in the Antarctic did not show any apparent response to a survey vessel moving at normal cruising speeds (about 12 knots [6.2 m/second]) at a distance of 5.5 nm; however, when the vessel drifted or moved at very slow speeds (about 1 knot [0.51 m/second]), many whales approached it (Leatherwood et al. 1982).

Although not expected to be in the Study Area, North Atlantic right whales tend not to respond to the sounds of oncoming vessels (Nowacek et al. 2004a). North Atlantic right whales continue to use habitats in high vessel traffic areas (Nowacek et al. 2004a). Studies show that North Atlantic right whales demonstrate little if any reaction to sounds of vessels approaching or the presence of the vessels themselves (Nowacek et al. 2004a, Terhune and Verboom 1999). Although this may minimize potential disturbance from passing ships, it does increase the whales' vulnerability to potential ship strike. The regulated approach distance for right whales is 500 yd. (460 m) (National Marine Fisheries Service 2001).

Using historical records, Watkins (1986) showed that the reactions of four species of mysticetes to vessel traffic and whale watching activities in Cape Cod had changed over the 25-year period examined (1957–1982). Reactions of minke whales changed from initially more positive reactions, such as coming toward the boat or research equipment to investigate, to more "uninterested" reactions toward the end of the study. Finback [fin] whales, the most numerous species in the area, showed a trend from initially more negative reactions, such as swimming away from the boat with limited surfacing, to more uninterested (ignoring) reactions, allowing boats to approach within 98.4 ft. (30 m). Right whales showed little change over the study period, with a roughly equal number of reactions judged to be negative and uninterested; no right whales were noted as having positive reactions to vessels. Humpback whales showed a trend from negative to positive reactions with vessels during the study period. The author concluded that the whales had habituated to the human activities over time (Watkins 1986).

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. An increase in feeding call rates and repetition by humpback whales in Alaskan waters is associated with vessel noise (Doyle et al. 2008). Melcón et al. (2012) also recently documented that blue whales increased the proportion of time spent producing certain types of calls when vessels were present. Conversely, decreases in singing activity by humpback whales have been noted near Brazil due to boat traffic (Sousa-Lima and Clark 2008). The Central North Pacific stock of humpback whales is the focus of whale-watching activities in both its feeding grounds (Alaska) and breeding grounds (Hawaii). Regulations addressing minimum approach distances and vessel operating procedures are in place in Hawaii and Alaska; however, with whale watching and other tourist-related activities (e.g., use of jet skis) growing, there is still concern that whales may abandon preferred habitats if the disturbance is too high (Allen and Angliss 2010).

Bernasconi et al. (2012) observed the reactions of six individual baleen whales in the presence of a fishing vessel conducting an acoustic survey of pelagic fisheries. The vessel was also equipped with a system for measuring the acoustic target strength of observed whales, which was the main purpose of the experiment. During the target strength measurements, the whales were free to interact with the vessel and were sighted at distances from 50 to 400 m while behavioral observations were made. During the fisheries survey, the vessel attempted to encircle the whale at a distance of approximately 200 m while acoustically surveying for fish. The results showed that breathing intervals of feeding whales did not increase during the fisheries survey, contrary to the anticipated result, and no increase in swimming speed was observed either. The authors did note a change in the swimming direction of the whales during the fisheries survey.

Odontocetes

In one study conducted by Würsig et al. (1998) in the Gulf of Mexico, sperm whales only reacted to vessels that approached within several hundred meters; otherwise, no reactions to the survey vessel were observed. Seventy-three percent of the sperm whales observed in the study had no reaction, and the remaining 27 percent were observed to dive abruptly as the vessel approached; however, all of these reactions occurred within 656 ft. (200 m) of the vessel. Another study suggested that the presence of vessels and aircraft associated with whale watching caused a decrease in blow intervals and a corresponding increase in the time whales spent at the surface (Richter et al. 2003). The presence of vessels seemed to cause the time from the first click to any subsequent clicks to decrease. Differences between the reactions of transient and resident sperm whales were also observed. Transient whales tended to react more frequently and strongly to the presence of vessels than resident whales, which encounter whale-watching vessels and aircraft more frequently (Richter et al. 2003). The smaller whale-watching and research vessels generate more noise in higher-frequency bands and are more likely to approach odontocetes directly and to spend more time near the individual whale. Reactions to military vessels are not well documented, but smaller whale-watching and research boats have been shown to cause these species to alter their breathing intervals and echolocation patterns (Richter et al. 2003; Richter et al. 2006).

Würsig et al. (1998) reported most *Kogia* species and beaked whales react negatively to vessels by quick diving and other avoidance maneuvers. Cox et al. (2006) noted very little information is available on the behavioral impacts of vessels or vessel noise on beaked whales. A single observation of vocal disruption of a foraging dive by a tagged Cuvier's beaked whale documented when a large noisy vessel was opportunistically present suggests that vessel noise may disturb foraging beaked whales (Aguilar de Soto et al. 2006). Tyack et al. (2011) note the result of a controlled exposure to pseudorandom noise suggests that beaked whales would respond to vessel noise and at similar received levels to those noted previously and for mid-frequency sonar.

Most delphinids have been observed reacting neutrally to vessels, although both avoidance and attraction behavior is known, particularly to instances of repeated disturbance by vessels (Hewitt 1985; Würsig et al. 1998; Lemon et al. 2006; Lusseau et al. 2006). Avoidance reactions include a decrease in resting behavior or change in travel direction (Bejder et al. 2006). Incidence of attraction includes harbor porpoises approaching a vessel and common, rough-toothed, and bottlenose dolphins bow riding and jumping in the wake of a vessel (Norris and Prescott 1961; Ritter 2002; Shane et al. 1986; Würsig et al. 1998). A study of vessel reactions by dolphin communities in the eastern tropical Pacific found that populations that were often the target of tuna purse-seine fisheries (spotted, spinner, and common dolphins) show evasive behavior when approached; however, populations that live closer to shore (within 100 nm; coastal spotted and bottlenose dolphins) that are not set on by purse-seine fisheries tend to be attracted to vessels (Archer et al. 2010a; Archer et al. 2010b). The presence of vessels has also been shown to interrupt feeding behavior in delphinids (Pirotta et al. 2015, Meissner et al. 2015).

Killer whales, the largest of the delphinids, are targeted by numerous small whale-watching vessels in the Pacific Northwest, and research suggests that whale-watching guideline distances may be insufficient to prevent behavioral disturbances (Noren et al. 2009). These vessels have measured source levels that ranged from 145 to 169 dB re 1 µPa at 1 m, and the sound they produce underwater has the potential to result in behavioral disturbance, interfere with communication, and affect the killer whales' hearing (Erbe 2002). Killer whales foraged significantly less and traveled significantly more when boats were within 328 ft. (100 m) of the whales (Kruse 1991; Lusseau et al. 2009; Trites and Bain 2000; Williams et al. 2002; Williams et al. 2009). These short-term feeding activity disruptions may have important long-term population-level effects (Lusseau et al. 2009; Noren et al. 2009). The reaction of the killer whales to whale-watching vessels may be in response to the vessel pursuing them, rather than to the noise of the vessel itself, or to the number of vessels in their proximity. For inland waters of Washington State, regulations were promulgated in 2011, restricting approach to within 200 yd. (183 m) of "whales." The approach regulations do not apply to "government vessels," which includes U.S. military vessels. Although these regulations were specifically developed to protect the endangered southern resident killer whales, the regulation reads "whales" and does not specify if it applies to only killer whales, all cetaceans, or marine mammals with a common name including the word "whale" (National Marine Fisheries Service 2011a). Navy standard practice is to avoid approaching marine mammals head on and to maneuver to maintain a mitigation zone of 500 yd. around detected whales, which is therefore more protective than the distance provided by the regulation.

Similar behavioral changes (increases in traveling and other stress-related behaviors) have been documented in Indo-Pacific bottlenose dolphins in Zanzibar (Christiansen et al. 2010; Englund and Berggren 2002; Stensland and Berggren 2007). Short-term displacement of dolphins due to tourist boat presence has been documented (Carrera et al. 2008), while longer term or repetitive/sustained displacement for some dolphin groups due to chronic vessel noise has been noted (Haviland-Howell et al. 2007; Miksis-Olds et al. 2007). Most studies of the behavioral reactions to vessel traffic of bottlenose dolphins have documented at least short-term changes in behavior, activities, or vocalization patterns when vessels are near, although the distinction between vessel noise and vessel movement has not been made clear in most cases (Acevedo 1991; Arcangeli and Crosti 2009; Berrow and Holmes 1999; Janik and Thompson 1996; Lusseau 2004; Mattson et al. 2005; Scarpaci et al. 2000). Guerra et al. (2014) demonstrated that bottlenose dolphins subjected to chronic noise from tour boats responded to “boat noise” by alterations in group structure and in vocal behavior, but they also found the dolphins’ reactions varied depending on whether the observing research vessel was approaching or moving away from the animals being observed.

Odontocetes have been shown to make short-term changes to vocal parameters such as intensity (Holt et al. 2008) as an immediate response to vessel noise, as well as increase the pitch, frequency modulation, and length of whistling (May-Collado and Wartzok 2008). Likewise, modification of multiple vocalization parameters has been shown in belugas residing in an area known for high levels of commercial traffic. These animals decreased their call rate, increased certain types of calls, and shifted upward in frequency content in the presence of small vessel noise (Lesage et al. 1999). Another study detected a measurable increase in the amplitude of their vocalizations when ships were present (Scheifele et al. 2005). Killer whales are also known to modify their calls during increased noise. For example, the source level of killer whale vocalizations was shown to increase with higher background noise levels associated with vessel traffic (the Lombard effect) (Holt et al. 2008). In addition, calls with a high-frequency component have higher source levels than other calls, which may be related to behavioral state, or may reflect a sustained increase in background noise levels (Holt et al. 2008). On the other hand, long-term modifications to vocalizations may be indicative of a learned response to chronic noise or of a genetic or physiological shift in the populations. This type of change has been observed from killer whales off the northwestern coast of the United States between 1973 and 2003. This population increased the duration of primary calls once a threshold in observed vessel density (e.g., whale watching) was reached, which has been suggested as a long-term response to increased masking noise produced by the vessels (Foote et al. 2004). Conversely, long-term modifications to vocalizations may be indicative of a learned response to sustained noise, or of a genetic or physiological shift in the populations. For example, the source level of killer whale vocalizations has been shown to increase with higher background noise levels associated with vessel traffic (the Lombard effect). In addition, calls with a high-frequency component have higher source levels than other calls, which may be related to behavioral state, or may reflect a sustained increase in background noise levels (Holt et al. 2008).

Behavioral Responses to Aircraft and Missile Overflights

The following paragraphs summarize what is known about the reaction of various marine mammal species to overhead flights of many types of fixed-wing aircraft, helicopters, and missiles. Thorough reviews of the subject and available information are presented in Richardson et al. (1995), Efroymson et al. (2001), Luksenburg and Parsons (2009), and Holst et al. (2011), including that the transmission of airborne sound into the water is generally limited to a narrow approximately 26 degree cone described by Snell’s law. The most common responses of cetaceans to overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping) (Nowacek et al. 2007). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Holst et al. 2011). Richardson et al. (1995) noted that marine mammal reactions to aircraft overflight largely consisted of opportunistic and anecdotal observations lacking clear distinction between reactions potentially caused by the noise of the aircraft and the visual cue an aircraft presents.

In addition, it was suggested that variations in the responses noted were due to generally other undocumented factors associated with overflight (Richardson et al. 1995). These factors could include aircraft type (single engine, multi-engine, jet turbine), flight path (centered on the animal, off to one side, circling, level and slow), environmental factors such as wind speed, sea state, cloud cover, and locations where native subsistence hunting continues.

Mysticetes

Mysticetes either ignore or occasionally dive in response to aircraft overflights (Koski et al. 1998; Efroymson et al. 2001). Richardson et al. (1995) reported that while data on the reactions of mysticetes are meager and largely anecdotal, there is no evidence that single or occasional aircraft flying above mysticetes causes long-term displacement of these mammals. In general, overflights above 1,000 ft. (305 m) do not cause a reaction and the NOAA has promulgated a regulation for Hawaiian Waters and the Hawaii Humpback Whale National Marine Sanctuary adopting this stand-off distance. For right whales, the stand-off distance for aircraft is 500 yd. (457 m) (National Marine Fisheries Service 2001).

Bowhead whales in the Beaufort Sea exhibited a transient behavioral response to fixed-wing aircraft and vessels. Reactions were frequently observed at less than 1,000 ft. (305 m) above sea level, infrequently observed at 1,500 ft. (457 m), and not observed at 2,000 ft. (610 m) above sea level (Richardson et al. 1995). Bowhead whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns. Behavioral reactions decreased in frequency as the altitude of the helicopter increased to 492 ft. (150 m) or higher. It should be noted that bowhead whales may have more acute responses to anthropogenic activity than many other marine mammals, because bowheads are often presented with limited egress due to limited open water between ice floes.

Odontocetes

Variable responses to aircraft have been observed in toothed whales, though overall little change in behavior has been observed during flyovers. Some toothed whales dove, slapped the water with their flukes or flippers, or swam away from the direction of the aircraft during overflights; others did not visibly react (Richardson et al. 1995).

Results from studies of reactions by sperm whales to aircraft overflights provide some insight into possible behavioral responses that could occur from military aircraft activity in the Study Area. One conclusion that can be drawn from these and other studies is that behavioral responses to aircraft in sperm whales are variable. During standard marine mammal surveys at an altitude of 750 ft. (229 m), some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after being sighted. Other authors have corroborated the variability in sperm whales' reactions to fixed-wing aircraft or helicopters (Green et al. 1992; Magalhaes et al. 2002; Richter et al. 2006; Richter et al. 2003; Smultea et al. 2008; Würsig et al. 1998). In one study, sperm whales showed no reaction to a helicopter until they encountered the downdrafts from the rotors (Richardson et al. 1995). In another study, a group of sperm whales responded to a circling aircraft (altitude of 800–1,100 ft. [244–335 m]) by moving closer together and forming a defensive fan-shaped semicircle, with their heads facing outward. Several individuals in the group turned on their sides, apparently to look up toward the aircraft (Smultea et al. 2008). Richter et al. (2003) reported that whale-watching aircraft apparently caused sperm whales to turn or change direction more sharply than would normally be expected. However, the presence of the aircraft did not affect the blow interval, amount of time at the surface, length of time to first click, or the frequency of aerial behavior (Richter et al. 2003). An important distinction between these studies, which focused on aircraft and vessels engaged in whale watching and the proposed military activities, is that military aircraft would not fly at low altitudes, hover over, or follow whales and, therefore, would not be expected to evoke similar types of responses.

Smaller delphinids generally react to overflights either neutrally or with a startle response (Würsig et al. 1998). The same species that show strong avoidance behavior to vessel traffic (*Kogia* species and beaked whales) also react to aircraft (Würsig et al. 1998). Beluga whales and bowhead whales reacted differently to aircraft overflights, exhibiting responses including diving, breaching, changing direction or behavior, and altering breathing patterns. Belugas reacted more frequently to a hovering or passing helicopter than bowheads. These reactions increased in frequency as the altitude of the helicopter dropped below 492 ft. (150 m). Belugas also reacted to the helicopter when it was sitting on the ice with its engines running, whereas bowheads showed almost no reaction (Patenaude et al. 2002). Both species showed similar reactions to a low flying (600 ft. [182 m]) fixed-wing aircraft at a distance of 820 ft. (250 m). Nevertheless, there is no evidence that single or occasional aircraft flying above odontocetes causes long-term displacement of these mammals (Richardson et al. 1995).

3.4.3.1.2.7 Repeated Exposures

Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with costs that can accumulate over time to cause long-term consequences for the individual. Animals repeatedly exposed to a stressor can become sensitized to the stressor if it is followed by a consequence (negative or positive), resulting in an escalating behavioral reaction over time (Bejder et al. 2009). Conversely, some animals may habituate to a stressor over time. If there is no consequence associated with a stressor, then the animal's response to repeated exposures to the stressor gradually wanes, and the animal becomes habituated. An animal's tolerance of a stressor (or disturbance) is an instantaneous measure of the animal's ability to "tolerate" the disturbance without responding (Bedjer et al. 2009). Increasing tolerance of a stressor indicates habituation whereas decreasing tolerance of a stressor indicates sensitization.

Repeated exposure to acoustic and other anthropogenic stimuli has been studied in several cases, especially as related to vessel traffic and whale watching. Common dolphins (*Delphinus* sp.) in New Zealand responded to dolphin-watching vessels by interrupting foraging and resting bouts, and took longer to resume behaviors in the presence of the vessel (Stockin et al. 2008). The authors speculated that repeated interruptions of the dolphins foraging behaviors could lead to long-term implications for the population. Bejder et al. (2006) studied responses of bottlenose dolphins to vessel approaches and found stronger and longer-lasting reactions in populations of animals that were exposed to lower levels of vessel traffic overall. The authors indicated that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area. Marine mammals that are more tolerant may stay in a disturbed area, whereas individuals that are more sensitive may leave for areas with less human disturbance. However, animals that remain in the area throughout the disturbance may be unable to leave the area for a variety of physiological or environmental reasons. Terrestrial examples of this abound as human disturbance and development displace more sensitive species, and tolerant animals move in to exploit the freed resources and fringe habitat (Barber et al. 2011; Francis et al. 2009). Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region if they do not become acclimated to the presence of the sound (Blackwell et al. 2004; Bejder et al. 2006; Teilmann et al. 2006). Gray whales in Baja California abandoned an historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. Whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al. 1984).

Over a shorter time scale, studies on the AUTEC instrumented range in the Bahamas have shown that some Blaineville's beaked whales may be resident during all or part of the year in the area, and that individuals may move to the periphery or off of the range during a sonar event. However, the whales would typically return to the range within 2–3 days following the sonar event (Tyack et al. 2011). Observed behavioral responses to the mid-frequency sonar included stopping echolocation and ascending from dives over longer time periods. Similar behaviors were recorded during the Navy sonar event and a controlled experiment using sonar playback and playback of killer whale calls. Even though the animals left the range during the sonar event, they are thought to have continued feeding at short distances (approximately 10 km) from the center of the range and the sound source. The results indicate that the whales may cease feeding behavior (halting echolocation) when the sound pressure level reaches 140 dB re 1 μPa (McCarthy et al. 2011; Tyack et al. 2011). Tyack et al. (2011) acknowledge that a beaked whale exposed to killer whale sounds may exhibit a heightened sensitivity and prolonged response influencing subsequent responses to sonar. Similarly, a whale exposed to sonar only a few hours after an initial exposure may also influence the behavioral response to the second exposure. Furthermore, the whales showed a greater sensitivity (reacting at a lower sound pressure level) to killer whale sounds than to the sonar, possibly because they associate the killer whale sounds with the presence of a predator.

Moore and Barlow (2013) noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. Moore and Barlow (2013) suggest that one reason for the decline in beaked whales from Canada to Mexico may be as a result of anthropogenic sound, including the use of sonar by the U.S. Navy in the fraction of the U.S. Pacific coast overlapped by the Southern California (SOCAL) Range Complex. The Navy trains and tests in the small fraction of that area in Southern California off San Diego. Although Moore and Barlow (2013) have noted a decline in the overall beaked whale population along the Pacific coast, in the small fraction of that area where the Navy has been training and testing with sonar and other systems for decades (the Navy's SOCAL Range Complex), higher densities and long-term residency by individual Cuvier's beaked whales suggest that the decline noted elsewhere is not apparent where Navy sonar use is most intense. Navy sonar training and testing is not conducted along a large part of the US West Coast from which Moore and Barlow (2013) drew their survey data. In Southern California, based on a series of surveys from 2006 to 2008 and a high number encounter rate, Falcone et al. (2009) suggested the ocean basin west of San Clemente Island may be an important region for Cuvier's beaked whales given the number of animals encountered there. Follow-up research (Falcone and Schorr 2012) in this same location suggests that Cuvier's beaked whales may have population sub-units with higher than expected residency, particularly in the Navy's instrumented Southern California Anti-Submarine Warfare Range. Photo identification studies in the SOCAL Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 15 percent having been seen in more than 1 year, and sightings spanning up to 4 years (Falcone and Schorr 2012). This finding is also consistent with concurrent results from passive acoustic monitoring that estimated regional Cuvier's beaked whale densities were higher than indicated by NMFS' broad scale visual surveys for the U.S. west coast (Hildebrand and McDonald 2009).

Moore and Barlow (2013) recognized the inconsistency between their hypothesis and the abundance trends in the region of SOCAL Range Complex, stating: "High densities are not obviously consistent with a hypothesis that declines are due to military sonar, but they do not refute the possibility that declines have occurred in these areas (i.e., that densities were previously even higher)." While it is possible that the high densities of beaked whale currently inhabiting the Navy's range were even higher before the Navy began training with sonar, there are no data available to test that hypothesis. Furthermore, the decline of beaked whales Moore and Barlow (2013) assert for other areas of the U.S. West Coast where the Navy does not conduct sonar training or testing limits the validity of their speculation about the effects of sonar on beaked whale populations. Mysticetes in the northeast tended to adjust to vessel traffic over a number of years, trending towards more neutral responses to passing vessels (Watkins 1986) indicating that some animals may habituate or otherwise learn to cope with high levels of human activity. Nevertheless, the long-term consequences of these habitat utilization changes are unknown, and likely vary depending on the species, geographic areas, and the degree of acoustic or other human disturbance.

3.4.3.1.2.8 Stranding

When a live or dead marine mammal swims or floats onto shore and becomes "beached" or incapable of returning to sea, the event is termed a "stranding" (Geraci et al. 1999; Geraci and Lounsbury 2005). Animals outside of their "normal" habitat are also sometimes considered "stranded" even though they may not have beached themselves. Under the U.S. Law, a stranding is an event in the wild that: "(A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance" (16 United States Code Section 1421h).

Marine mammals are subjected to a variety of natural and anthropogenic factors, acting alone or in combination, which may cause a marine mammal to strand on land or die at-sea (Geraci et al. 1999; Geraci and Lounsbury 2005). Even for the fractions of more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for the majority of strandings remain undetermined. Natural factors related to strandings include, for example, the availability of food, predation, disease, parasitism, climatic influences, and aging (Bradshaw et al. 2006; Culik 2004; Geraci et al. 1999; Geraci and Lounsbury 2005; Hoelzel 2003; National Research Council 2006; Perrin and Geraci 2002; Walker et al. 2005). Anthropogenic factors may include, for example, pollution (Marine Mammal Commission 2010; Elfes et al. 2010; Hall et al. 2006a; Hall et al. 2006b; Jepson et al. 2005; Tabuchi et al. 2006), vessel strike (Berman-Kowalewski et al. 2010; de Stephanis and Urquiola 2006; Geraci and Lounsbury 2005; Jensen and Silber 2003; Laist et al. 2001), fisheries interactions (Look 2011; Read et al. 2006; Geijer and Read 2013), entanglement (Baird and Gorgone 2005; Johnson and Allen 2005; Saez et al. 2012), and noise (Richardson 1995; National Research Council 2003; Cox et al. 2006).

Along the coasts of the continental United States and Alaska between 2001 and 2009, there were on average approximately 1,400 cetacean strandings and 4,300 pinniped strandings (5,700 total) per year (National Marine Fisheries Service 2011a, b, c). Several "mass stranding" events—strandings that involve two or more individuals of the same species (excluding a single cow-calf pair)—that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduced sound into the marine environment. An in-depth discussion of strandings is presented in the technical report, *Marine Mammal Strandings Associated With U.S. Navy Sonar Activities* (U.S. Department of the Navy 2012).

Sonar use during exercises involving the U.S. Navy (most often in association with other nations' defense forces) has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira Island, Portugal in 2000; the Canary Islands in 2002; and Spain in 2006 (Marine Mammal Commission 2006). These five mass stranding events resulted in about 40 known stranding deaths among cetaceans consisting mostly of beaked whales with a potential causal link to sonar (International Council for the Exploration of the Sea 2005). Although these events have served to focus attention on the issue of impacts resulting from the use of sonar, as Ketten (2012) recently pointed out, "ironically, to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result anthropogenic noise exposures, including sonar." In these previous strandings, exposure to non-impulse acoustic energy has been considered a potential indirect cause of the death of marine mammals (Cox et al. 2006). One hypothesis regarding a potential cause of the strandings is tissue damage resulting from "gas and fat embolic syndrome" (Fernandez et al. 2005; Jepson et al. 2003; Jepson et al. 2005). Models of nitrogen saturation in diving marine mammals have been used to suggest that altered dive behavior might result in the accumulation of nitrogen gas such that the potential for nitrogen bubble formation is increased (Houser et al. 2001a; Houser et al. 2001b; Zimmer and Tyack 2007). If so, this mechanism might explain the findings of gas and bubble emboli in stranded beaked whales. It is also possible that stranding is a behavioral response to a sound under certain contextual conditions and that the subsequently observed physiological effects (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) were the result of the stranding rather than direct physical impact from exposure to sonar (Cox et al. 2006).

As the International Council for the Exploration of the Sea (2005) noted, taken in context of marine mammal populations in general, sonar is not a major threat or significant portion of the overall ocean noise budget. This has also been demonstrated by monitoring in areas where the Navy operates (Bassett et al. 2010; Baumann-Pickering et al. 2010; Hildebrand et al. 2011; McDonald et al. 2006; Tyack et al. 2011). Regardless of the direct cause, the Navy considers potential sonar related strandings important and continues to fund research and work with scientists to better understand circumstances that may result in strandings.

The Navy prepared a technical report as a supporting document to the EIS/OEIS that presents specific information regarding marine mammal stranding events that may have been associated with U.S. Navy activities (U.S. Department of the Navy 2012). Additionally, this report provides general information on other threats to marine mammals (natural and anthropogenic) that may cause or contribute to strandings.

During a Navy training event on 4 March 2011 at the SSTC (San Diego, California), three

Criteria for Estimating Mortality Reflects a Conservative Overestimate:

Navy's modeling uses onset mortality criteria for estimating effects that provides a conservative overestimate of likely mortalities. These mortality criteria are based on receipt of impulse energy where 1 percent of the animals exposed would not survive the injuries received. All animals within the range to onset mortality are quantified as mortalities, although many animals would actually recover from or otherwise survive the injury that is the basis of the criteria. The Navy's modeling also assumes that all animals are calf-sized, resulting in additional over-prediction of effects since the likelihood of mortality decreases as an animal's mass increases, and most marine mammals are adult-sized not calf-sized (see Section 3.4.3.1.4.1, Mortality and Injury from Explosives) long-beaked common dolphins were found dead immediately after an underwater detonation associated with the event.[3] In addition to the three dolphin mortalities at the detonation site, a fourth dolphin was discovered dead 3 days later (on 7 March near Oceanside, California) approximately 37 nm north of the training event location. It is not known when this fourth dolphin died, but it is assumed to be between the time of the training event and the discovery at the stranding location. Details, such as individual dolphins' depth and distance from the explosive source at the time of detonation, could not be estimated; however, the stranding was assessed as having been related to the training event at the SSTC (Danil and St. Ledger 2011).

These dolphin mortalities are the only known occurrence of a U.S. Navy training event involving impulse energy (underwater detonation) that has resulted in injury to a marine mammal. Despite this being a rare occurrence, Navy has reviewed training requirements, safety procedures, and potential mitigation measures and, along with NMFS, is determining appropriate changes to implement to reduce the potential for this to occur in the future. Discussions of procedures associated with these and other training and testing events are presented in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), which details all mitigations.

The potential for marine mammals to die as a result of military activities is very low, and the numbers resulting from Navy modeling reflect a very conservative approach.[4] In comparison to strandings, serious injury, and death from non-military human activities affecting the oceans, major causes include commercial shipping vessels strike (e.g., Berman-Kowalewski et al. 2010; Silber et al. 2010), impacts from urban pollution (e.g., O'Shea & Brownell 1994; Hooker et al. 2007), and annual fishery-related entanglement, bycatch, injury, and mortality (e.g., Baird and Gorgone 2005, Forney and Kobayashi 2007; Saez et al. 2012; Geijer and Read 2013), which have been estimated worldwide to be orders of magnitude greater (hundreds of thousands of animals versus tens of animals) than the few potential injurious impacts that could be possible as a result of military activities (Culik 2004; International Council for the Exploration of the Sea 2005; Read et al. 2006). This does not negate the potential influence of mortality or additional stress to small, regionalized sub-populations which may be at greater risk from human related mortalities (fishing, vessel strike, sound) than populations with larger oceanic level distributions, but overall the military's impact in the oceans and inland water areas where training and testing occurs is small by comparison to other human activities.

3.4.3.1.3 Long-Term Consequences to the Individual and the Population

Long-term consequences to a population are determined by examining changes in the population growth rate. Individual effects that could lead to a reduction in the population growth rate include mortality or injury (that removes animals from the reproductive pool), loss in hearing sensitivity (which depending on severity could impact navigation, foraging, predator avoidance, or communication),

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[3] During this underwater detonation training event, a pod of 100 to 150 dolphins were observed moving towards the explosive event's 700 yd. (640 m) exclusion zone monitored by a personnel in a safety boat and participants in a dive boat. Within the exclusion zone, approximately 5 minutes remained on a timed fuse connected to a single 8.76 lb. (3.97 kg) explosive charge weight (C-4 and detonation cord) set at a depth of 48 ft. (14.6 m), approximately 0.5–0.75 nm from shore. Although the dive boat was placed between the pod and the explosive in an effort to guide the dolphins away from the area, that effort was unsuccessful. The Navy informed NMFS, recovered the three animals, and transferred them to the local stranding network for necropsy.

[4] Navy's metric for modeling and quantifying "mortality" provides a conservative overestimate of the mortalities likely to occur. The mortality criteria are based on an injury from impulse energy for which only 1 percent of the animals receiving that injury would die. All animals within the range to onset mortality are modeled as mortalities, although many would actually survive. With the exception of rare Navy vessel strikes to large whales, marine mammals are not expected to die as a result of future Navy training and testing activities.

chronic stress (which could make individuals more susceptible to disease), displacement of individuals (especially from preferred foraging or mating grounds), and disruption of social bonds (due to masking of conspecific signals or displacement) (see Appendix H, Biological Resource Methods, and U.S. Department of the Navy 2012). However, the long-term consequences of any of these effects are difficult to predict because individual experience and time can create complex contingencies, especially for intelligent, long-lived animals like marine mammals. While a lost reproductive opportunity could be a measureable cost to the individual, the outcome for the animal, and ultimately the population, can range from insignificant to significant. Any number of factors, such as maternal inexperience, years of poor food supply, or predator pressure, could result in a lost reproductive opportunity, but these events may be "made up" during the life of a normal healthy individual. The same holds true for exposure to human-generated sound sources. These biological realities must be taken into consideration when assessing risk, uncertainties about that risk, and the feasibility of preventing or recouping such risks. All too often, the long-term consequence of relatively trivial events like short-term masking of a conspecific's social sounds, or a single lost feeding opportunity, is exaggerated beyond its actual importance by focusing on the single event and not the important variable, which is the individual and its lifetime parameters of growth, reproduction, and survival.

A causal link between anthropogenic noise, animal communication, and individual impacts, as well as population viability over the long term, is difficult to quantify and assess (McGregor et al. 2013, Read et al. 2014). For instance, Read et al. (2014) reviewed select terrestrial literature on individual and population response to sound and described a necessary framework to assess future direct and indirect fitness impacts. The difficulty with assessing behavioral effects associated with anthropogenic noise, individually and cumulatively, is the confounding nature of the issue. Depending on the situation, there may or may not be indirect effects resulting from a complex interactive dependence based on age class, prior experience, and behavioral state at the time of exposure, as well as influences by other non-sound related factors (Knight and Swaddle 2011, Ellison et al. 2012, Goldbogen et al. 2013, McGregor et al. 2013, Read et al. 2014, Williams et al. 2014). McGregor et al. (2013) summarized some studies on sound impacts and described two types of possible effects based on the studies they reviewed: (1) an apparent effect of noise on communication, but with a link between demonstrated proximate cost and ultimate cost in survival or reproductive success being inferred rather than demonstrated; and (2) studies showing a decrease in population density or diversity in relation to noise, but with a relationship that is usually a correlation, so that factors other than noise or its effect on communication might account for the relationship (McGregor et al. 2013). Within the ocean environment, there is a complex interaction of considerations needed in terms of defining cumulative anthropogenic impacts that has to also be considered in context of natural variation and climate change (Boyd and Hutchins 2012). These considerations can include environmental enhancers that improve fitness, additive effects from two or more factors, multiplicity where response from two or more factors is greater than the sum of individual effects, synergism between factors and response, antagonism as a negative feedback between factors, acclimation as a short-term individual response, and adaptation as a long-term population change (Boyd and Hutchins 2012). To address determination of cumulative effects and response changes due to processes such as habituation, tolerance, and sensitization, future experiments over an extended period of time require further research (Bejder et al. 2009, Blickley et al. 2012, Read et al 2014).

The linkage between a stressor such as sound and its immediate behavioral or physiological consequences for the individual, and then the subsequent effects on that individual's vital rates (growth, survival, and reproduction), and the consequences, in turn, for the population have been reviewed in National Research Council (2005). The Population Consequences of Acoustic Disturbance model (see National Research Council 2005) proposed a quantitative methodology for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translate into biologically significant consequences to the population. Population models are well known from many fields in biology, including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population, such as the mean values for survival age, lifetime reproductive success, and recruitment of new individuals into the population. The time-scale of the inputs in a population model for long-lived animals such as marine mammals is on the order of seasons, years, or life stages (e.g., neonate, juvenile, reproductive adult), and are often concerned only with the success of individuals from one time period or stage to the next. Unfortunately, for acoustic and explosive impacts to marine mammal populations, many of the inputs required by population models are not known.

The best assessment of long-term consequences from training and testing activities will be to monitor the populations over time within the Study Area. A recent U.S. workshop on Marine Mammals and Sound (Fitch et al. 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed monitoring plans for protected marine mammals and sea turtles occurring on Navy ranges with the goal of assessing the impacts of training and testing activities on marine species and the effectiveness of the Navy's current mitigation practices. Although there are limited data available for the MITT Study Area (Mobley 2007), results of intensive monitoring from 2009 to 2012 by independent scientists and Navy observers in SOCAL Range Complex and Hawaii Range Complex have recorded an estimated 256,000 marine mammals with no evidence of distress or unusual behavior observed during Navy activities (see Section 3.4.5.2, Summary of Observations During Previous Navy Activities, for a broader discussion on this topic). Continued monitoring efforts over time will be necessary to completely evaluate the long-term consequences of exposure to sound sources.

3.4.3.1.4 Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals

If proposed military activities introduce sound or explosive energy into the marine environment, an analysis of potential impacts to marine mammals is conducted. To do this, quantifiable information about the sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions is needed.

3.4.3.1.4.1 Mortality and Injury from Explosives

There is a considerable body of laboratory data on actual injury from impulse sound, usually from explosive pulses, obtained from tests with a variety of lab animals (mice, rats, dogs, pigs, sheep, and other species). Onset Mortality, Onset Slight Lung Injury, and Onset Slight Gastrointestinal (GI) Tract Injury represent a series of effects with decreasing likelihood of serious injury or lethality. Primary impulse injuries from explosive blasts are the result of differential compression and rapid re-expansion of adjacent tissues of different acoustic properties (e.g., between gas-filled and fluid-filled tissues or between bone and soft tissues). These injuries usually manifest themselves in the gas-containing organs (lung and gut) and auditory structures (e.g., rupture of the eardrum across the gas-filled spaces of the outer and inner ear) (Craig and Hearn 1998; Craig Jr. 2001).

Criteria and thresholds for predicting mortality and injury to marine mammals from impulse sources were initially developed for the U.S. Navy shock trials of the SEAWOLF submarine (Craig and Hearn 1998) and *USS WINSTON S. CHURCHILL* (DDG-81) surface ship (Craig Jr. 2001). These criteria and thresholds were also adopted by NMFS in several Final Rules issued under the MMPA (63 Federal

Register [FR] 230; 66 FR 87; 73 FR 121; 73 FR 199). These criteria and thresholds were revised as necessary based on new science, used for the shock trial of the U.S. Navy amphibious transport dock ship *USS MESA VERDE* (LPD-19) (Finneran and Jenkins 2012), and were subsequently adopted by NMFS in their MMPA Final Rule authorizing the *USS MESA VERDE* shock trial (73 FR 143). Upper and lower frequency limits of hearing are not applied for lethal and injurious exposures. These criteria and their origins are explained in greater detail in Finneran and Jenkins (2012) covering the development of the thresholds and criteria for assessment of impacts.

Mortality and Slight Lung Injury

In air or submerged, the most commonly reported internal bodily injury was hemorrhaging in the fine structure of the lungs (Richmond et al. 1973). Biological damage is governed by the impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973; Yelverton et al. 1973; Yelverton et al. 1975; Yelverton and Richmond 1981). Therefore, impulse was used as a metric upon which internal organ injury could be predicted. A review of the predicted effects from impulse sources on marine mammals up to 1995 is provided by Ketten (1998). The research estimates impact zones for marine mammals ranging from TTS to mortality for two hypothetical underwater explosions based on extrapolated data from fish, submerged terrestrial animals, and humans.

Species-specific masses are used for determining impulse-based thresholds because it most closely represents effects to individual species. The Navy's Thresholds and Criteria Technical Report (Finneran and Jenkins 2012) provides a nominal conservative body mass for each species based on newborn weights. In some cases, body masses were extrapolated from similar species rather than the listed species. The scaling of lung volume to depth is conducted for all species since data are from experiments with terrestrial animals held near the water's surface.

Because the thresholds for onset of mortality and onset of slight lung injury are proportional to the cube root of body mass, the use of all newborn, or calf, weights rather than representative adult weights results in an over-estimate of effects to animals near an explosion. The range to onset mortality for a newborn compared to an adult animal of the same species can range from less than twice to over four times as far from an explosion, depending on the differences in calf versus adult sizes for a given species and the size of the explosion. Considering that injurious high pressures due to explosions propagate away from detonations in a roughly spherical manner, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.

The use of onset mortality and onset slight lung injury is a conservative method to estimate potential mortality and recoverable (non-mortal, non-PTS) injuries. When analyzing impulse-based effects, all animals within the range to these thresholds are assumed to experience the effect. The onset mortality and onset slight lung injury criteria are based on the impulse at which these effects are predicted for 1 percent of animals; the portion of animals affected would increase closer to the explosion. As discussed above, according to the Navy's analysis all animals receive the effect vice a percentage; therefore, these criteria conservatively over-estimate the number of animals that could be killed or injured.

Impulse thresholds for onset mortality and slight injury are indexed to 75 and 93 lb. (34 and 42 kg) for mammals, respectively (Richmond et al. 1973). The regression curves based on these experiments were plotted, such that a prediction of mortality to larger animals could be determined as a function of positive impulse and mass (Craig Jr. 2001). After correction for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass, as used in the Goertner injury model (Goertner 1982), the minimum impulse for predicting onset of extensive (i.e., 50 percent) lung injury for "1 percent

Mortality" (defined as most survivors had moderate blast injuries and should survive on their own) and slight lung injury for "0 percent Mortality" (defined as no mortality, slight blast injuries) (Yelverton and Richmond 1981) were derived for each species. As the mortality threshold, the Navy chose to use the minimum impulse level predictive of 50 percent lung injury, even though this injury is likely to result in mortality to only 1 percent of exposed animals. Because the mortality criteria represents a threshold at which 99 percent of exposed animals would be expected to recover, this analysis overestimates the impact on individuals and populations from exposure to impulse sources.

Onset of Gastrointestinal Tract Injury

Evidence indicates that gas-containing internal organs, such as lungs and intestines, are the principle damage sites from shock waves in submerged terrestrial mammals (Clark and Ward 1943; Greaves et al. 1943; Richmond et al. 1973; Yelverton et al. 1973). Furthermore, slight injury to the gastrointestinal tract may be related to the magnitude of the peak shock wave pressure over the hydrostatic pressure and would be independent of the animal's size and mass (Goertner 1982). Slight contusions to the gastrointestinal tract were reported during small charge tests (Richmond et al. 1973), when the peak was 237 dB re 1 µPa.

There are instances where injury to the gastrointestinal tract could occur at a greater distance from the source than slight lung injury, especially for animals near the surface. Gastrointestinal tract injury from small test charges (described as "slight contusions") was observed at peak pressure levels as low as 104 pounds per square inch (known as psi), equivalent to a sound pressure level of 237 dB re 1 µPa (Richmond et al. 1973). This criterion was previously used by Navy and NMFS for ship shock trials (Finneran and Jenkins 2012; 63 FR 230, 66 FR 87, 73 FR 143).

3.4.3.1.4.2 Frequency Weighting

Frequency-weighting functions are used to adjust the received sound level based on the sensitivity of the animal to the frequency of the sound. The weighting functions de-emphasize sound exposures at frequencies to which marine mammals are not particularly sensitive. This effectively makes the acoustic thresholds frequency-dependent, which means they are applicable over a wide range of frequencies and therefore applicable for a wide range of sound sources. Frequency-weighting functions, deemed "M-weighting" functions by the authors, were proposed by Southall et al. (2007) to account for the frequency bandwidth of hearing in marine mammals. These M-weighting functions were derived for each marine mammal hearing group based on an algorithm using the range of frequencies that are within 80 dB of an animal or group's best hearing sensitivity at any frequency (Southall et al. 2007). The Southall et al. (2007) M-weighting functions are nearly flat between the lower and upper cutoff frequencies, and thus were believed to represent a conservative approach to assessing the effects of sound (Figure 3.4-2). For the purposes of this analysis, the Navy will refer to these as Type I auditory weighting functions.

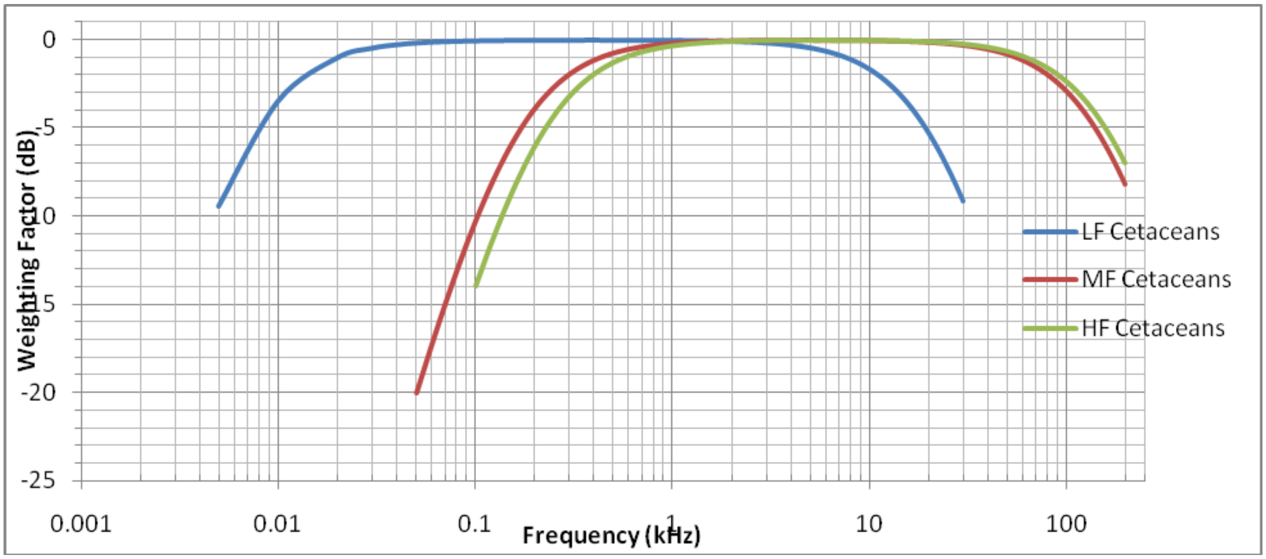

Figure 3.4-2: Type I Auditory Weighting Functions Modified from the Southall et al. (2007) M-Weighting Functions

Finneran and Jenkins (2012) considered data since Southall et al (2007) to determine if any adjustments to the weighting functions were appropriate. Only two published experiments suggested that modification of the mid-frequency cetacean auditory weighting function was necessary (see Finneran and Jenkins [2012] for more details on that modification not otherwise provided below). The first experiment measured TTS in a bottlenose dolphin after exposure to pure tones with frequencies from 3 to 28 kHz (Finneran et al. 2010b). These data were used to derive onset-TTS values as a function of exposure frequency, and demonstrate that the use of a single numeric threshold for onset-TTS, regardless of frequency, is not correct. The second experiment examined how subjects perceived the loudness of sounds at different frequencies to derive equal loudness contours (Finneran and Schlundt 2011). These data are important because human auditory weighting functions are based on equal loudness contours. The dolphin equal loudness contours provide a means to generate auditory weighting functions in a manner directly analogous to the approach used to develop safe exposure guidelines for people working in noisy environments (National Institute for Occupational Safety and Health 1998).

Taken together, the recent higher-frequency TTS data and equal loudness contours provide the underlying data necessary to develop new weighting functions, referred to as Type II auditory weighting functions, to improve accuracy and avoid underestimating the impacts on animals at higher frequencies, as shown on Figure 3.4-3. To generate the new Type II weighting functions, Finneran and Schlundt (2011) substituted lower and upper frequency values which differ from the values used by Southall et al. (2007). The new Type II weighting curve predicts appreciably higher susceptibility for frequencies above 3 kHz. Since data below 3 kHz are not available, the original Type I weighting functions from Southall et al. (2007) were substituted below this frequency. Low- and high-frequency cetacean weighting functions were extrapolated from the dolphin data as well, because of the suspected similarities of greatest susceptibility at best frequencies of hearing. Similar Type II weighting curves were not developed for pinnipeds since their hearing is markedly different from cetaceans, and because they do not hear as well at higher frequencies and so their weighting curves did not require the same adjustment (see Finneran and Jenkins 2012 for additional details).

Frequency Weighting Example:

A spinner dolphin, a mid-frequency cetacean (see 3.4.2.3.2, Mid-Frequency Cetaceans), receives a 10 kHz ping from a sonar with a sound exposure level (SEL) of 180 dB re 1 μPa^2-s. To discern if this animal may suffer a TTS, the received level must first be adjusted using the appropriate Type II auditory weighting function for mid-frequency cetaceans (see 3.4.2.3.2, Mid-Frequency Cetaceans). At 10 kHz, the weighting factor for mid-frequency cetaceans is -3 dB, which is then added to the received level (180 dB re 1 μPa^2-s + (-3 dB) = 177 dB re 1 μPa^2-s) to yield the weighted received level. This is compared to the Non-Impulse Mid-Frequency Cetacean TTS threshold (178 dB re 1 μPa^2-s; see Table 3.4-3). Since the adjusted received level is less than the threshold, TTS is not likely for this animal from this exposure.

The Type II auditory cetacean weighting functions (Figure 3.4-3) are applied to the received sound level before comparing it to the appropriate sound exposure level thresholds for TTS or PTS, or the impulse behavioral response threshold. For some criteria, received levels are not weighted before being compared to the thresholds to predict effects. These include the peak pressure criteria for predicting impulse TTS and PTS, the acoustic impulse metrics used to predict onset-mortality and slight lung injury, and the thresholds used to predict behavioral responses from beaked whales from non-impulse sound. Beaked whales have unique behavioral criteria based on data that show these animals to be especially sensitive to sound. To account for their sensitivity to sound, beaked whale non-impulse behavioral criteria are unweighted (i.e., the received level is not weighted before comparing it to the threshold) (Finneran and Jenkins 2012).

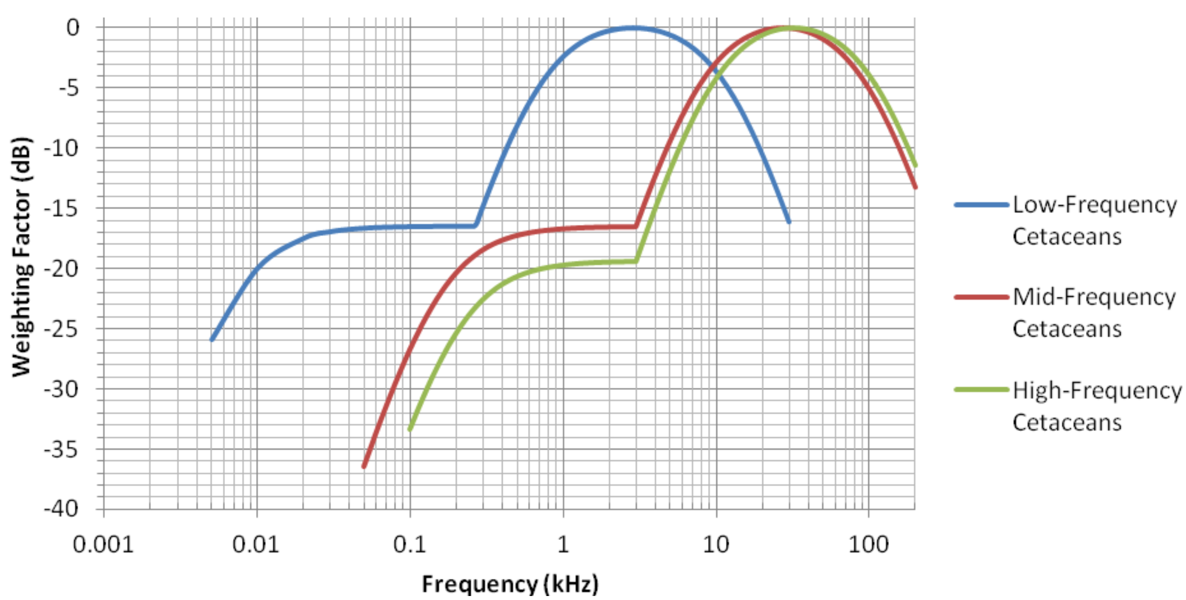

Figure 3.4-3: Type II Weighting Functions for Low-, Mid-, and High-Frequency Cetaceans

Summation of Energy From Multiple Sources

In most cases, an animal's received level will be the result of exposure to a single sound source. In some scenarios, however, multiple sources will be operating simultaneously, or nearly so, creating the potential for accumulation of energy from multiple sources. Energy is summed for multiple exposures of similar source types. For sonars, including use of multiple systems within any scenario, energy will be summed for all exposures within a frequency band, with the cumulative frequency exposure bands defined as 0–1.0 kHz (low-frequency sources), 1.1–10.0 kHz (mid-frequency sources), 10.1–100.0 kHz (high-frequency sources), and 100.1–200.0 kHz (very high-frequency sources). Sources operated at frequencies above 200 kHz are considered to be inaudible to all groups of marine mammals and are not analyzed in the quantitative modeling of exposure levels. After the energy has been summed within each frequency band, the band with the greatest amount of energy is used to evaluate the onset of PTS or TTS. For explosives, including use of multiple explosives in a single scenario, energy is summed across the entire frequency band.

Hearing Loss – Temporary and Permanent Threshold Shift

Criteria for physiological effects from non-impulse sources are based on TTS and PTS with thresholds based on cumulative sound exposure levels. The onset of TTS or PTS from exposure to impulse sources is predicted using a sound exposure level-based threshold in conjunction with a peak pressure threshold. The horizontal ranges are then compared, with the threshold producing the longest range being the one used to predict effects. For multiple exposures within any 24-hour period, the received sound exposure level (SEL) for individual events are accumulated for each animal.

Since no studies have been designed to intentionally induce PTS in marine mammals due to moral and ethical issues inherent in such a study, onset-PTS levels have been estimated using empirical TTS data obtained from marine mammals and relationships between TTS and PTS established in terrestrial mammals.

Temporary and permanent threshold shift thresholds are based on TTS onset values for impulse and non-impulse sounds obtained from representative species of mid- and high-frequency cetaceans. The Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis technical report (Finneran and Jenkins 2012) provides a detailed explanation of the selection of criteria and derivation of thresholds for temporary and permanent hearing loss for marine mammals. Section 3.4.3.1.2.3 (Hearing Loss) provided the specific meanings of temporary and permanent threshold shift as used in this EIS/OEIS. Table 3.4-3 provides a summary of acoustic thresholds for TTS and PTS for marine mammals from sonar and other active acoustic sources (non-impulse sources), and Table 3.4-4 provides a summary of acoustic thresholds for TTS, PTS, injury, and mortality from explosives (impulse sources).

Temporary Threshold Shift from Sonar and Other Active Acoustic Sources

Temporary threshold shift involves no tissue damage, is by definition temporary, and therefore is not considered injury. TTS values for mid-frequency cetaceans exposed to non-impulse sound are derived from multiple studies (Finneran et al. 2005; Schlundt et al. 2000; Mooney et al. 2009a; Finneran et al. 2010a; Finneran and Schlundt 2010) from two species, bottlenose dolphins and beluga whales. Especially notable are data for frequencies above 3 kHz, where bottlenose dolphins have exhibited lower TTS onset thresholds than at 3 kHz (Finneran and Schlundt 2010; Finneran and Schlundt 2011). This difference in TTS onset at higher frequencies is incorporated into the weighting functions (Table 3.4-3).

Table 3.4-3: Acoustic Criteria and Thresholds for Predicting Physiological Effects on Marine Mammals from Sonar and Other Active Acoustic Sources

Hearing Group	Species	Physiological	
		Onset TTS	Onset PTS
Low-Frequency Cetaceans	All mysticetes	178 dB re 1 μPa²-s SEL (Type II Weighting)	198 dB re 1 μPa²-s SEL (Type II Weighting)
Mid-Frequency Cetaceans	Dolphins, beaked whales, and medium and large toothed whales	178 dB re 1 μPa²-s SEL (Type II Weighting)	198 dB re 1 μPa²-s SEL (Type II Weighting)
High-Frequency Cetaceans	Porpoises and *Kogia* spp.	152 dB re 1 μPa²-s SEL (Type II Weighting)	172 dB re 1 μPa²-s SEL (Type II Weighting)

Notes: dB = decibels, SEL = sound exposure level, TTS = temporary threshold shift, PTS = permanent threshold shift, μPa²-s = micropascal squared second

Previously, there had been no direct measurements of TTS from non-impulse sound in high-frequency cetaceans. Lucke et al. (2009) measured TTS in a harbor porpoise exposed to a small seismic airgun and those results are reflected in the current impulse sound TTS thresholds described below. The beluga whale, which had been the only species for which both impulse and non-impulse TTS data existed, has a non-impulse TTS onset value about 6 dB above the (weighted) impulse threshold (Finneran et al. 2002; Schlundt et al. 2000). Therefore, 6 dB was added to the harbor porpoise's impulse TTS threshold demonstrated by Lucke et al. (2009) to derive the non-impulse TTS threshold used in the current Navy modeling for high-frequency cetaceans. A report on the first direct measurements of TTS from non-impulse sound was recently presented by Kastelein et al. (2012) for harbor porpoise. These new data are consistent with the current harbor porpoise thresholds used in the modeling of effects from sonar and other active acoustic sources.

There are no direct measurements of TTS or hearing abilities for low-frequency cetaceans. The Navy has applied mid-frequency cetacean thresholds to the low-frequency cetacean group as described in Finneran and Jenkins (2012) on the development of the thresholds and criteria. The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict TTS.

Temporary Threshold Shift from Explosives

The TTS sound exposure level thresholds for cetaceans are consistent with the thresholds approved by NMFS for the *USS MESA VERDE* ship shock trial (73 FR 143: 43130–43138, 24 July 2008) and are more representative of TTS induced from impulses (Finneran et al. 2002; Finneran and Jenkins 2012) rather than pure tones (Schlundt et al. 2000). In most cases, a total weighted sound exposure level is more conservative than greatest sound exposure level in one-third-octave bands, which was used prior to the *USS MESA VERDE* ship shock trials. Impulse threshold criteria for mid-frequency cetaceans from Finneran et al. (2002) are used for low-frequency cetaceans, because there are no data on TTS obtained directly from low-frequency cetaceans. High-frequency cetacean TTS thresholds are based on research by Lucke et al. (2009), who exposed harbor porpoises to pulses from a single airgun. The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict TTS (Table 3.4-4).

Table 3.4-4: Criteria and Thresholds for Predicting Physiological Effects on Marine Mammals[1]

Group	Species	Onset TTS	Onset PTS	Onset Slight GI Tract Injury	Onset Slight Lung Injury[2]	Onset Mortality[1]
Low Frequency Cetaceans	All mysticetes	172 dB re 1 µPa²-s SEL (Type II weighting) or 224 dB re 1 µPa Peak SPL (unweighted)	187 dB re 1 µPa²-s SEL (Type II weighting) or 230 dB re 1 µPa Peak SPL (unweighted)			
Mid-Frequency Cetaceans	Most delphinids, medium and large toothed whales	172 dB re 1 µPa²-s SEL (Type II weighting) or 224 dB re 1 µPa Peak SPL (unweighted)	187 dB re 1 µPa²-s SEL (Type II weighting) or 230 dB re 1 µPa Peak SPL (unweighted)	237 dB re 1 µPa (unweighted)	Note 1	Note 2
High Frequency Cetaceans	Porpoises and *Kogia* spp.	146 dB re 1 µPa²-s SEL (Type II weighting) or 195 dB re 1 µPa Peak SPL (unweighted)	161 dB re 1 µPa²-s SEL (Type II weighting) or 201 dB re 1 µPa Peak SPL (unweighted)			
Note 1 $= 39.1M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec$			Note 2 $= 91.4M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec$			

[1]Additional information on the derivation and use of criteria thresholds is presented in the technical report, *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis* (Finneran and Jenkins 2012).
[2] Impulse calculated over a delivery time that is the lesser of the initial positive pressure duration or 20 percent of the natural period of the assumed-spherical lung adjusted for animal size and depth.
Notes: GI = gastrointestinal, M = mass of animals in kg, D_{Rm} = depth of receiver (animal) in meters,
SEL = sound exposure level (in units of dB re µPa²-s)
SPL = sound pressure level (in units of dB re 1 µPa),
dB re 1 µPa = decibels referenced to 1 micropascal,
dB re µPa²-s = decibels referenced to 1 micropascal squared second

Permanent Threshold Shift from Sonar and Other Acoustic Sources

There are no direct measurements of PTS onset in marine mammals. Well-understood relationships between terrestrial mammalian TTS and PTS have been applied to marine mammals. Threshold shifts up to 40–50 dB have been induced in terrestrial mammals without resultant PTS (Miller et al. 1963; Ward et al. 1958; Ward et al. 1959). These data would suggest that 40 dB of TTS would be a reasonable limit for approximating the beginning of PTS for marine mammals exposed to continuous sound. Data from terrestrial mammal testing (Ward et al. 1958; Ward et al. 1959b) show growth of TTS by 1.5–1.6 dB for every 1 dB increase in exposure level. The difference between measurable TTS onset (6 dB) and the selected 40 dB upper safe limit of TTS yields a difference in TTS of 34 dB which, when divided by a TTS growth function of 1.6, indicates that an increase in exposure of 21 dB would result in 40 dB of TTS. For simplicity and additional conservatism, the number was rounded down to 20 dB (Southall et al. 2007).

Therefore, exposures to sonar and other active acoustic sources with levels 20 dB above those producing TTS are used to predict the threshold at which a PTS exposure would result (Table 3.4-3). For example, an onset-TTS criterion of 195 dB re 1 µPa^2-s would have a corresponding onset-PTS criterion of 215 dB re 1 µPa^2-s. This extrapolation process is identical to that recently proposed by Southall et al. (2007). The method overestimates effects (i.e., predicts greater effects) beyond those actually observed in tests on a bottlenose dolphin (Schlundt et al. 2006; Finneran et al. 2010a) indicating that this is a conservative approach to predicting onset-PTS.

The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict PTS.

Permanent Threshold Shift from Explosives

Since marine mammal PTS data from impulse exposures do not exist, onset-PTS levels for these animals are estimated by adding 15 dB re 1 µPa^2-s to the sound exposure level-based TTS threshold and by adding 6 dB re 1 µPa to the peak pressure based thresholds. These relationships were derived by Southall et al. (2007) from impulse noise TTS growth rates in chinchillas. The appropriate frequency weighting function for each species group is applied using the resulting sound exposure level-based thresholds, as shown on Table 3.4-4, to predict PTS.

3.4.3.1.4.3 Behavioral Responses

Behavioral response criteria are used to estimate the number of animals that may exhibit a behavioral response. In this analysis, animals may be behaviorally harassed in each modeled scenario (using the Navy Acoustic Effects Model) or within each 24-hour period, whichever is shorter. Therefore, the same animal could have a behavioral reaction multiple times over the course of a year.

Sound from Sonar and Other Active Sources

Potential behavioral effects to marine mammals from sonar and other active acoustic sources underwater were predicted using a behavioral response function for most animals. The received sound level is weighted with Type I auditory weighting functions (Southall et al. 2007; see Figure 3.4-2) before the behavioral response function is applied. There are exceptions made for beaked whales, which have unique behavioral criteria based on specific data that show these animals to be especially sensitive to sound. Beaked whale non-impulse behavioral criteria are unweighted; without weighting the received level before comparing it to the threshold (Finneran and Jenkins 2012).

Behavioral Response Functions

The Navy worked with NMFS to define a mathematical function used to predict potential behavioral effects to mysticetes (Figure 3.4-4) and odontocetes (Figure 3.4-5) from mid-frequency sonar (National Marine Fisheries Service 2008a). This effects analysis assumes that the potential consequences of exposure to sonar and other active acoustic sources on individual animals would be a function of the received sound pressure level (dB re 1 µPa). Although the response functions differ, the intercepts on each figure highlight that each function has a 50 percent probability of harassment at a received level of 165 dB SPL.

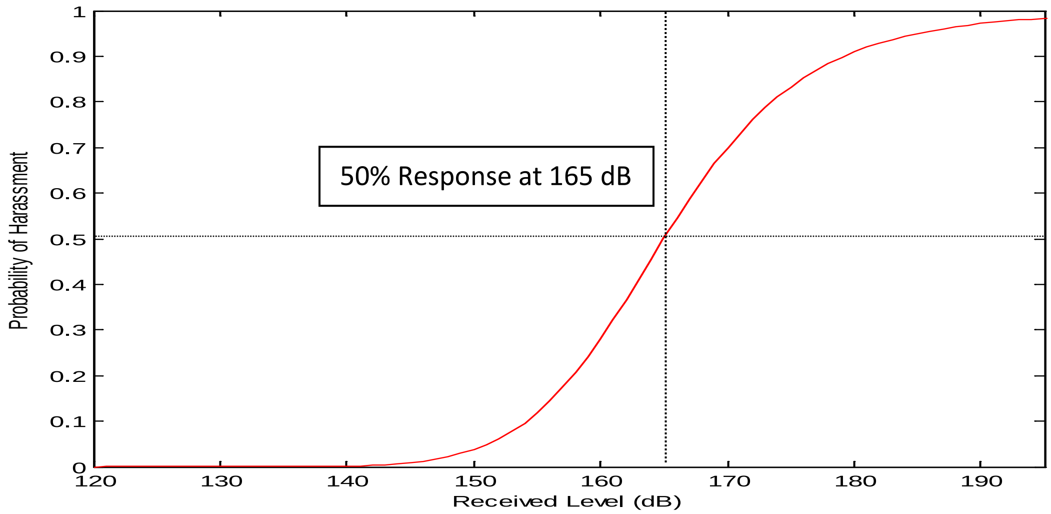

Figure 3.4-4: Behavioral Response Function Applied to Mysticetes

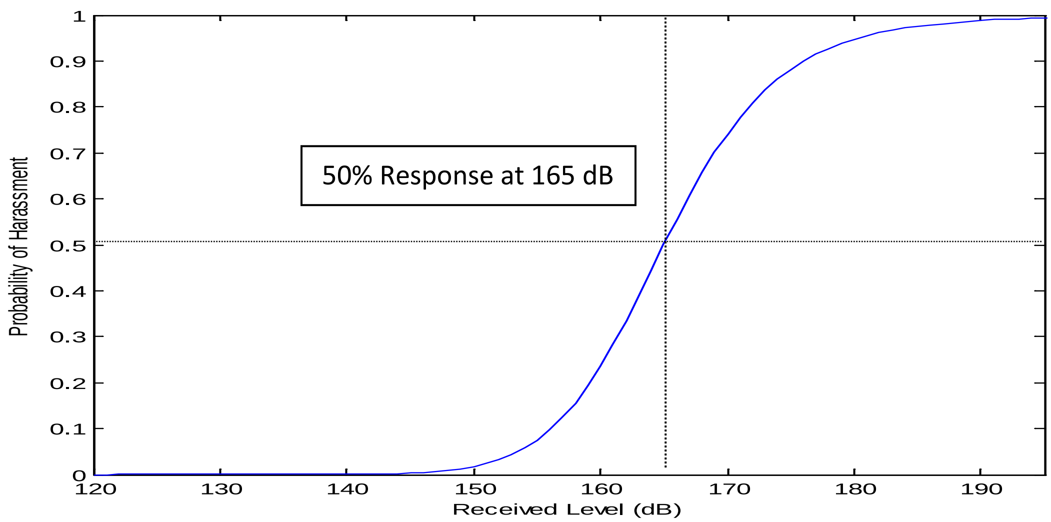

Figure 3.4-5: Behavioral Response Function Applied to Odontocetes

The behavioral response function applied to mysticetes differs from that used for odontocetes in having a shallower slope, which results in the inclusion of more behavioral events at lower amplitudes, consistent with observational data from North Atlantic right whales (Nowacek et al. 2007). These analyses assume that sound poses a negligible risk to marine mammals if they are exposed to sound pressure levels below a certain basement value. The values used in this analysis are based on three sources of data: behavioral observations during TTS experiments conducted at the Navy Marine Mammal Program and documented in Finneran et al. (2001, 2003, and 2005, Finneran and Schlundt 2004); reconstruction of sound fields produced by *USS SHOUP* associated with the behavioral responses of killer whales observed in Haro Strait (Fromm 2004a, b; National Marine Fisheries Service 2005; U.S. Department of the Navy 2004); and observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components documented in Nowacek et al. (2004a).

In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of human-made noise. In other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson et al. 1995; Wartzok et al. 2003; Southall et al. 2007). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict. Therefore, the behavioral response functions represent a relationship that is deemed to be generally accurate, but may not be true in specific circumstances.

Specifically, the behavioral response function treats the received level as the only variable that is relevant to a marine mammal's behavioral response. However, many other variables, such as the marine mammal's gender, age, and prior experience; the activity it is engaged in during a sound exposure; its distance from a sound source; the number of sound sources; and whether the sound sources are approaching or moving away from the animal can be critically important in determining whether and how a marine mammal will respond to a sound source (Southall et al. 2007; Ellison et al. 2012). Currently available data do not allow for incorporation of these other variables in the current behavioral response functions; however, the response function represents the best use of the data that are available. Furthermore, the behavioral response functions do not differentiate between different types of behavioral reactions (e.g., area avoidance, diving avoidance, or alteration of natural behavior) or provide information regarding the predicted consequences of the reaction.

The behavioral response function is used to estimate the percentage of an exposed population that is likely to exhibit behaviors that would qualify as harassment (as that term is defined by the MMPA applicable to military readiness activities, such as the Navy's testing and training with MFA sonar) at a given received level of sound (Table 3.4-5). For example, at 165 dB SPL (dB re 1 µPa rms), the risk (or probability) of harassment is defined according to this function as 50 percent. This means that 50 percent of the individuals exposed at that received level would be predicted to exhibit a significant behavioral response.

Table 3.4-5: Summary of Behavioral Thresholds for Marine Mammals

Group	Behavioral Thresholds for Sonar and Other Active Acoustic Sources	Behavioral Thresholds for Explosions (SEL)
Low-Frequency Cetaceans	SPL: BRF_1 (Type I weighting)	167 dB re 1 µPa^2-s (Type II Weighting)
Mid-Frequency Cetaceans	SPL: BRF_2 (Type I weighting)	167 dB re 1 µPa^2-s (Type II Weighting)
High-Frequency Cetaceans	SPL: BRF_2 (Type I weighting)	141 dB re 1 µPa^2-s (Type II Weighting)
Beaked Whales	140 dB re 1 µPa (Unweighted)	167 dB re 1 µPa^2-s (Type II Weighting)

Notes: dB re 1 µPa = decibels referenced to 1 micropascal, dB re 1 µPa^2-s = decibels referenced to 1 micropascal squared second, BRF = Behavioral Response Function, SPL = sound pressure level, SEL = sound exposure level

Beaked Whales

The inclusion of a special behavioral response criterion for beaked whales of the family Ziphiidae is new to these Phase II criteria and is based on Southall et al. (2012a). It has been speculated for some time that beaked whales might have unusual sensitivities to sound due strandings which occurred in conjunction with mid-frequency sonar use, even in areas where other species were more abundant (D'Amico et al. 2009; U.S. Department of the Navy 2012), but there were not sufficient data to support a separate treatment for beaked whales until recently. With the recent publication of results from beaked whale monitoring and experimental exposure studies on the Navy's instrumented range in the Bahamas (McCarthy et al. 2011; Tyack et al. 2011), there are now statistically strong data demonstrating that beaked whales tend to avoid actual naval mid-frequency sonar in real anti-submarine training scenarios, playbacks of sonar, and playbacks of killer whale vocalizations, as well as other anthropogenic sounds. Tyack et al. (2011) report that, in reaction to sonar playbacks, most beaked whales stopped echolocating, made long slow ascent, and moved away from the sound. During an exercise using mid-frequency sonar, beaked whales avoided the area at a distance from the sonar where the received level was "around 140 dB" (SPL) and once the exercise ended, beaked whales re-inhabited the center of exercise area within 2–3 days (Tyack et al. 2011). The Navy has therefore adopted a 140 dB re 1 µPa sound pressure level threshold for behavioral effects for all beaked whales (see Table 3.4-5).

Since the development of the criterion, analysis of the data from the 2010 and 2011 field seasons of the Southern California Behavioral Responses Study have been published. The study, DeRuiter et al. (2013a), provides similar evidence of Cuvier's beaked whale sensitivities to sound based on two controlled exposures. Two whales, one in each season, were tagged and exposed to simulated MFA sonar at distances of 3.4–9.5 km. The 2011 whale was also incidentally exposed to MFA sonar from a distant naval exercise (~ 118 km away). Received levels from the MFA sonar signals during the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa rms, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure to distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Because the sample size was limited (controlled exposures during a single dive in both 2010 and 2011) and baseline behavioral data were obtained from different stocks and geographic areas (i.e., Hawaii and Mediterranean Sea), the Navy relied on the studies at AUTEC that analyzed beaked whale responses to actual naval exercises using MFA sonar to evaluate potential behavioral responses by beaked whales to proposed training and testing activities using sonar and other active acoustic sources.

Impulse Sound from Explosives

If more than one impulse event occurs within any given 24-hour period within a training or testing activity, criteria are applied to predict the number of animals that may have behavioral reaction. For multiple impulse events (with the exception of pile driving) the behavioral threshold used in this analysis is 5 dB less than the TTS onset threshold (in sound exposure level) (see Table 3.4-5). This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulse TTS testing (Schlundt et al. 2000).

Some multiple impulse events, such as certain gunnery exercises, may be treated as a single impulse event because a few explosions occur closely spaced within a very short time (a few seconds). For single impulses at received sound levels below hearing loss thresholds, the most likely behavioral response is a brief alerting or orienting response. Since no further sounds follow the initial brief impulse, significant behavioral reactions would not be expected to occur. This reasoning was applied to ship shock trials (63 FR 230; 66 FR 87; 73 FR 143) and is extended to the criteria used in this analysis.

Since impulse events can be quite short, it may be possible to accumulate multiple received impulses at sound pressure levels above the energy-based criterion and still not be considered a behavioral take. The Navy treats all individual received impulses as if they were 1 second long for the purposes of calculating cumulative sound exposure level for multiple impulse events. For example, five impulses, each 0.1 second long, received at a Type II weighted SPL of 167 dB SPL would equal a 164 dB sound pressure level, and would not be predicted as leading to a significant behavioral response in MF or HF cetaceans. However, if the five 0.1-second pulses are treated as a 5-second exposure, it would yield an adjusted value of approximately 169 dB, exceeding the threshold of 167 dB sound exposure level. For impulses associated with explosions that have durations of a few microseconds, this assumption greatly overestimates effects based on sound exposure level metrics such as TTS and PTS and behavioral responses.

Appropriate weighting values will be applied to the received impulse in one-third octave bands and the energy summed to produce a total weighted sound exposure level value. For impulsive behavioral criteria, the new weighting functions (Figure 3.4-5) are applied to the received sound level before being compared to the threshold.

Impulse Sound from Airguns

Existing NMFS risk criteria are applied to the unique impulse sounds generated by airguns (Table 3.4-6) Weir (2008) reported minimal (or no) behavioral responses from humpback whales and sperm whales to airguns used during seismic surveys. Atlantic spotted dolphins did show overt avoidance behavior during airgun use, but readily approached the vessel to bow ride when the airgun was not in use. All observed responses occurred within 200 m of the vessel conducting the surveys.

Table 3.4-6: Airgun Thresholds Used in this Analysis to Predict Effects on Marine Mammals

Species Groups	Underwater Airgun Criteria (sound pressure level, dB re 1 µPa)	
	Level A Injury Threshold	Level B Disturbance Threshold
Cetaceans (whales, dolphins, porpoises)	180 dB rms	160 dB rms

Notes: (1) rms = root mean square, dB re 1 µPa = decibels referenced to 1 micropascal; (2) Root mean square calculation is based on the duration defined by 90 percent of the cumulative energy in the impulse.

3.4.3.1.5 Quantitative Analysis

The Navy performed a quantitative analysis to estimate the number of marine mammals that could be affected by acoustic sources or explosives used during military training and testing activities. Inputs to the quantitative analysis included marine mammal density estimates, marine mammal depth occurrence distributions, oceanographic and environmental data, marine mammal hearing data, and criteria and thresholds for levels of potential effects. The quantitative analysis consists of computer-modeled estimates from the Navy Acoustic Effects Model and a post-model analysis to determine the number of potential mortalities and harassments. The model calculates sound energy propagation from sonar, other active acoustic sources, and explosives during naval activities; the sound or impulse received by animat dosimeters representing marine mammals distributed in the area around the modeled activity; and whether the sound or impulse received by a marine mammal exceeds the thresholds for effects. The model estimates are then further analyzed to consider animal avoidance and implementation of mitigation measures, resulting in final estimates of potential effects due to military training and testing.

A number of computer models and mathematical equations can be used to predict how energy spreads from a sound source (e.g., sonar or underwater detonation) to a receiver (e.g., dolphin or sea turtle). See the Acoustic and Explosives Primer (Section 3.0.4) and a more detailed discussion in Appendix I (Acoustic and Effects Primer) for background information about how sound travels through the water. Basic underwater sound models calculate the overlap of energy and marine life using assumptions that account for the many, variable, and often unknown factors that can influence the result. Assumptions in previous and current Navy models have intentionally erred on the side of overestimation when there are unknowns or when the addition of other variables was not likely to substantively change the final analysis. For example, because the ocean environment is extremely dynamic and information is often limited to a synthesis of data gathered over wide areas and requiring many years of research, known information tends to be an average of a seasonal or annual variation. El Niño Southern Oscillation events of the ocean-atmosphere system are an example of dynamic change where unusually warm or cold ocean temperatures are likely to redistribute marine life and alter the propagation of underwater sound energy. Previous Navy modeling therefore made some assumptions indicative of a maximum theoretical propagation for sound energy (such as a perfectly reflective ocean surface and a flat seafloor). More complex computer models build upon basic modeling by factoring in additional variables in an effort to be more accurate by accounting for such things as bathymetry and an animal's likely presence at various depths.

The Navy has developed a set of data and new software tools for quantification of estimated marine mammal impacts from military activities. This new approach is the resulting evolution of the basic model previously used by Navy and reflects a more complex modeling approach as described below. Although this more complex computer modeling approach (i.e., the Navy Acoustic Effects Model) accounts for various environmental factors affecting acoustic propagation in more detail than previously considered, the current modeling (like all previous modeling) and resulting preliminary exposure numbers do not factor in: (1) the likelihood that a marine mammal would attempt to avoid repeated exposures to a sounds or explosions underwater, (2) that a marine mammal would avoid an area of intense activity where a training or testing event may be focused, and (3) implementation of Navy mitigation (e.g., stopping sonar transmissions when a detected marine mammal is within a certain distance of a ship; see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring, for details). In short, naval activities are modeled as though an activity would occur regardless of proximity to detected marine mammals and without any horizontal movement by the animal away from the sound source or human activities (e.g., without accounting for likely animal avoidance) because the science necessary to support that level of modeling complexity is beyond what is currently available. Therefore, the final step in the assessment of acoustic effects is to consider the implementation of mitigation and the possibility that marine mammals would avoid continued or repeated sound exposures to complete the analysis of potential impacts from the proposed action under the various alternatives.

The additional post-model quantification has been undertaken to further refine the numerical analysis of acoustic effects to include animal behavior such as avoidance of sound sources and avoidance of areas of activity before use of a sound source or explosive or during use of repeated explosives, and to account for protections afforded by implementation of standard Navy mitigations (see Marine Species Modeling Team 2013). The sections below describe the steps of the quantitative analysis of acoustic effects.

3.4.3.1.5.1 Marine Species Density Data

A quantitative analysis of impacts on a species requires data on the abundance and distribution of the species population in the potentially impacted area. The most appropriate unit of metric for this type of analysis is density, which is defined as the number of animals present per unit area.

There is no single source of density data for every area, species, and season because of the fiscal costs, resources, and effort involved in providing enough survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the MITT Study Area, the Navy needed to compile data from multiple sources. To develop a database of marine species density estimates, the Navy, in consultation with NMFS experts at the two science centers (Southwest Fisheries Science Center and Pacific Islands Fisheries Science Center) overlapping the MITT, adopted a protocol to select the best available data sources based on species, area, and season (see Navy's Pacific Marine Species Density Database Technical Report; U.S. Department of the Navy 2013c). The resulting Geographic Information System database includes one single spatial and seasonal density value for every marine mammal and sea turtle species present within the MITT Study Area.

The Navy Marine Species Density Database includes a compilation of the best available density data from several primary sources and published works including survey data from NMFS within the U.S. Economic Exclusion Zone and a Navy sponsored survey in waters of the MITT Study Area (Fulling et al. 2011). NMFS is the primary agency responsible for estimating marine mammal and sea turtle density within the United States exclusive economic zone. NMFS publishes annual Stock Assessment Reports for various regions of U.S. waters and covers all stocks of marine mammals within those waters. The majority of species that occur in the MITT Study Area are covered by the Pacific Region Stock Assessment Report (Carretta et al. 2013). Other independent researchers often publish density data or research covering a particular marine mammal species, which is integrated into the NMFS Stock Assessment Reports.

For most cetacean species, abundance is estimated using line-transect methods that employ a standard equation to derive densities based on sighting data collected from systematic ship or aerial surveys. More recently, habitat-based density models have been used effectively to model cetacean density as a function of environmental variables (e.g., Barlow et al. 2009). Habitat-based density models allow predictions of cetacean densities on a finer spatial scale than traditional line-transect analyses because cetacean densities are estimated as a continuous function of habitat variables (e.g., sea surface temperature, water depth, etc.). Within most of the world's oceans, however, there have not been enough systematic surveys to allow for line-transect density estimation or the development of habitat models. To get an approximation of the cetacean species distribution and abundance for unsurveyed areas, in some cases it is appropriate to extrapolate data from areas with similar oceanic conditions where extensive survey data exist. Habitat Suitability Index or Relative Environmental Suitability have also been used in data-limited areas to estimate occurrence based on existing observations about a given species' presence and relationships between basic environmental conditions (Kaschner et al. 2006).

3.4.3.1.5.2 Upper and Lower Frequency Limits

The Navy adopted a single frequency cutoff at each end of a functional hearing group's frequency range, based on the most liberal interpretations of their composite hearing abilities (see Finneran and Jenkins 2012) for details involving derivation of these values). These are not the same as the values used to calculate weighting curves, but instead exceed the demonstrated or anatomy-based hypothetical upper and lower limits of hearing within each group. Table 3.4-7 provides the lower and upper frequency limits for each species group. Sounds with frequencies below the lower frequency limit, or above the upper frequency limit, are not analyzed with respect to auditory effects for a particular group.

Table 3.4-7: Lower and Upper Cutoff Frequencies for Marine Mammal Functional Hearing Groups Used in this Acoustic Analysis

Functional Hearing Group	Limit (Hertz)	
	Lower	Upper
Low-Frequency Cetaceans	5	30,000
Mid-Frequency Cetaceans	50	200,000
High-Frequency Cetaceans	100	200,000

3.4.3.1.5.3 Navy Acoustic Effects Model

For this analysis of military training and testing activities at sea, the Navy developed a set of software tools and compiled data for the quantification of predicted acoustic impacts to marine mammals. These databases and tools collectively form the Navy Acoustic Effects Model. Details of this model's processes and the description and derivation of the inputs are presented in the Navy's Determination of Acoustic Effects Technical Report (Marine Species Modeling Team 2013).

The Navy Acoustic Effects Model improves upon previous modeling efforts in several ways (e.g., U.S. Department of the Navy 2008a, 2008b; Scheckłman et al. 2011). First, unlike earlier methods that modeled sources individually, the Navy Acoustic Effects Model has the capability to run all sources within a scenario simultaneously, providing a more realistic depiction of the potential effects of an activity. Second, previous models calculated sound received levels within set volumes of water and spread animals uniformly across the volumes; in the Navy Acoustic Effects Model, animats (virtual animals) are distributed nonuniformly based on higher resolution species-specific density, depth distribution, and group size information, and animats serve as dosimeters, recording energy received at their location in the water column. Third, a fully three-dimensional environment is used for calculating sound propagation and animat exposure in the Navy Acoustic Effects Model, rather than a two-dimensional environment where the worst case sound pressure level across the water column is always encountered. Finally, current efforts incorporate site-specific bathymetry, sound speed profiles, wind speed, and bottom properties into the propagation modeling process rather than the flat-bottomed provinces used during earlier modeling (Marine Species Monitoring Team 2012). The following paragraphs provide an overview of the Navy Acoustic Effects Model process and its more critical data inputs.

Using information on the likely density of marine mammals in the area being modeled, Navy Acoustic Effects Model derives an abundance (total number of individuals) and distributes the resulting number of animats into an area bounded by the maximum distance that energy propagates out to a criterion threshold value (energy footprint). For example, for non-impulsive sources, all animats that are predicted to occur within a range that could receive sound pressure levels greater than or equal to 120 dB re 1 µPa are distributed. These animats are distributed based on density differences across the area, the group (pod) size, and known depth distributions (dive profiles). Animats change depths every 4 minutes but do not otherwise mimic actual animal behaviors, such as avoidance or attraction to a stimulus (horizontal movement), or foraging, social, or traveling behaviors.

Schecklman et al. (2011) argue that static distributions underestimate acoustic exposure compared to a model with fully three-dimensionally moving animals. However, their static method is different from the Navy Acoustic Effects Model in several ways. First, they distribute the entire population at depth with respect to the species-typical depth distribution histogram, and those animats remain static at that position throughout the entire simulation. In the Navy Acoustic Effects Model, animats are placed horizontally dependent on nonuniform density information, and then move up and down over time within the water column by integrating species-typical depth distribution information. Second, for the static method, they calculate acoustic received level for designated volumes of the ocean and then sum the animats that occur within that volume, rather than using the animats themselves as dosimeters, as in the Navy Acoustic Effects Model. Third, Schecklman et al. (2011) ran 50 iterations of the moving distribution to arrive at an average number of exposures, but because they rely on uniform horizontal density (and static depth density), only a single iteration of the static distribution is realized. In addition to moving the animats vertically, the Navy Acoustic Effects Model overpopulates the animats over a nonuniform density and then resamples the population a number of times to arrive at an average number of exposures as well. Tests comparing fully moving distributions and static distributions with vertical position changes at varying rates were compared during development of the Navy Acoustic Effects Model. For position updates occurring more frequently than every 5 minutes, the number of estimated exposures was similar between the Navy Acoustic Effects Model and the fully moving distribution; however, computational time was much longer for the fully moving distribution.

The Navy Acoustic Effects Model calculates the likely propagation for various levels of energy (sound or pressure) resulting from sonar and other active acoustic sources or impulse sources (e.g., explosives) used during a training or testing event. This is done taking into account the actual bathymetric relief and bottom types (e.g., reflective), and estimated sound speeds and sea surface roughness at an event's location. Platforms (such as a ship using one or more sound sources) are modeled as moving across an area whose size is representative of what would normally occur during a training or testing scenario. The model uses typical platform speeds and event durations. Moving source platforms either travel along a predefined track or move along straight-line tracks from a random initial course, reflecting at the edges of a predefined boundary. Static sound sources are stationary in a fixed location for the duration of a scenario. Modeling locations were chosen based on historical data where activities have been ongoing and in an effort to include all the environmental variation within the Study Area where similar events might occur in the future.

The Navy Acoustic Effects Model then tracks the energy received by each animat within the energy footprint of the event and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds. Predicted effects to the animats are then converted using actual marine mammal densities, and the highest order effect predicted for a given animal is assumed. Each scenario or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine mammal could be impacted during each independent scenario or 24-hour period. In few instances, although the activities themselves all occur within the Study Area, sound may propagate beyond the boundary of the Study Area. Any exposures occurring outside the boundary of the Study Area are included in the model-estimated impacts for each alternative. The Navy Acoustic Effects Model provides the initial predicted impacts to marine species (based on application of multiple conservative assumptions which are assumed to overestimate impacts), which are then further analyzed to produce final estimates used in the Navy's MMPA take requests and ESA risk analyses (see Section 3.4.3.2, Marine Mammal Avoidance of Sound Exposures, for further information on additional analyses).

3.4.3.1.5.4 Model Assumptions and Limitations

There are limitations to the data used in the Navy Acoustic Effects Model, and the results must be interpreted with consideration for these known limitations. Output from the Navy Acoustic Effects Model relies heavily on the quality of both the input parameters and impact thresholds and criteria. When there was a lack of definitive data to support an aspect of the modeling (such as lack of well-described diving behavior for all marine species), conservative assumptions believed to overestimate the number of exposures were chosen:

- Marine mammals (animats in the model) are modeled as being underwater and facing the source and therefore are always predicted to receive the maximum sound level (e.g., the model does not account for conditions such as body shading, porpoising out of the water, or an animal raising its head above water). Some odontocetes have been shown to have directional hearing, with best hearing sensitivity facing a sound source and higher hearing thresholds for sounds propagating toward the rear or side of an animal (Kastelein et al. 2005; Mooney et al. 2008; Popov and Supin 2009).
- Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological effects such as hearing loss, especially for slow moving or stationary sound sources in the model.
- Animats are stationary horizontally and therefore do not avoid the sound source, unlike in the wild where animals would most often avoid exposures at higher sound levels, especially those exposures that may result in PTS.
- Animats are assumed to receive the full impulse of the initial positive pressure wave due to an explosion, although the impulse-based thresholds (onset mortality and onset slight lung injury) assume an impulse delivery time adjusted for animal size and depth. Therefore, these impacts are overestimated at farther distances and increased depths.
- Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating the temporary or permanent hearing loss, because there are not sufficient data to estimate a hearing recovery function for the time between exposures.
- Mitigation measures implemented during many training and testing activities were not considered in the model (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). In reality, sound-producing activities would be reduced, stopped, or delayed if marine mammals are detected within the mitigation zones around sound sources.

Because of these inherent model limitations and simplifications, initial predicted model results must be further analyzed, considering such factors as the range to specific effects and the likelihood of successfully implementing mitigation measures. This analysis uses a number of factors in addition to the acoustic model results to predict acoustic effects to marine mammals as presented in the following section.

3.4.3.2 Marine Mammal Avoidance of Sound Exposures

Marine mammals may avoid underwater sound exposures by either avoiding areas with high levels of anthropogenic activity or moving away from a sound source. Because the Navy Acoustic Effects Model does not consider horizontal movement of animats, including avoidance of human activity or sounds, it overestimates the number of marine mammals that would be exposed to sound sources that could cause injury. Therefore, the potential for avoidance is considered in the post-model analysis. The consideration of avoidance during use of sonar and other active acoustic sources and during use of explosives is described below and discussed in more detail in Section 3.4.3.1.2 (Analysis Background and Framework).

3.4.3.2.1 Avoidance of Human Activity

Cues preceding the commencement of an event (e.g., multiple vessel presence and movement, aircraft overflight) may result in some animals departing the immediate area, even before active sound sources begin transmitting. Beaked whales have been observed to be especially sensitive to human activity (Tyack et al. 2011; Pirotta et al. 2012), which is accounted for by using a low threshold for behavioral disturbance due to exposure to sonar and other active acoustic sources (see Section 3.4.3.1.2, Analysis Background and Framework).

Therefore, for certain military activities preceded by high levels of vessel activity (multiple vessels) or hovering aircraft, beaked whales are assumed to avoid the activity area prior to the start of a sound-producing activity. Model-estimated effects during these types of activities are adjusted so that high level sound impacts to beaked whales (those causing PTS during use of sonar and other active acoustic sources and those causing mortality due to explosives) are considered to be TTS and injury, respectively, due to animals moving away from the activity and into a lower effect range.

3.4.3.2.2 Avoidance of Repeated Exposures

Marine mammals would likely avoid repeated high level exposures to a sound source that could result in injuries (e.g., PTS). Therefore, the model-estimated effects are adjusted to account for marine mammals swimming away from a sonar or other active source and away from multiple explosions to avoid repeated high level sound exposures. Avoidance of repeated sonar exposures is discussed further in Section 3.4.4.1.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources), and avoidance of repeated explosive exposures is discussed further in Section 3.4.4.2.2 (Avoidance Behavior and Mitigation Measures as Applied to Explosions).

3.4.3.3 Implementing Mitigation to Reduce Sound Exposures

The Navy implements mitigation measures (described in Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) during sound-producing activities, including halting or delaying use of a sound source or explosives when marine mammals are observed in the mitigation zone. The Navy Acoustic Effects Model estimates acoustic effects without taking into account any shutdown or delay of the activity when marine mammals are detected; therefore, the model over-estimates impacts to marine mammals within mitigation zones. The post-model adjustment considers and quantifies the potential for highly effective mitigation to reduce the likelihood or risk of PTS due to exposure to sonar and other active acoustic sources and to reduce the likelihood of PTS, injuries, and mortalities due to explosives.

Two factors are considered when quantifying the effectiveness of mitigation: (1) the sightability of each species that may be present in the mitigation zone, which is affected by species-specific characteristics; and (2) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity. The mitigation zones proposed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) encompass the estimated ranges to injury (including the range to mortality for explosives) for a given source.

Mitigation is considered in the quantified reduction of model-predicted effects when the mitigation zone can be fully or mostly observed prior to and during a sound-producing activity. Mitigation for each training or testing event is considered in its entirety, taking into account the different ways an event's activities may take place as part of that event (some scenarios involve different mitigation zones, platforms, or number of Lookouts). The ability to observe the range to mortality (for explosive activities only) and the range to potential injury (for all sound-producing activities) were estimated for each training or testing event. Mitigation was considered in the acoustic analysis as follows:

- If the entire mitigation zone can be continuously visually observed based on the platform(s), number of Lookouts, and size of the range to effects zone, the mitigation is considered fully effective (Effectiveness = 1).
- If over half of the mitigation zone can be continuously visually observed or if there is one or more of the scenarios within the activity for which the mitigation zone cannot be continuously visually observed (but for the majority of the scenarios the range to effects zone can be continuously visually observed), the mitigation is considered mostly effective (Effectiveness = 0.5).
- If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, the mitigation is not considered as an adjustment factor in the acoustic effects analysis.

Integral to the ability of Lookouts to detect marine mammals in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability. The Navy considered what applicable data were available to numerically approximate the sightability of marine mammals and determined that the standard "detection probability" referred to as g(0) was most appropriate. The abundance of marine mammals is typically estimated using line-transect analyses (Buckland et al. 2001), in which g(0) is the probability of detecting an animal or group of animals on the transect line (the straight-line course of the survey ship or aircraft). This detection probability is derived from systematic line-transect marine mammal surveys based on species-specific estimates for vessel and aerial platforms. Estimates of g(0) are available from peer-reviewed marine mammal line-transect survey reports, generally provided through research conducted by the NMFS Science Centers.

There are two separate components of g(0): perception bias and availability bias (Marsh and Sinclair 1989). Perception bias accounts for marine mammals that are on the transect line and detectable, but were simply missed by the observer. Various factors influence the perception bias component of g(0), including species-specific characteristics (e.g., behavior and appearance, group size, and blow characteristics), viewing conditions during the survey (e.g., sea state, wind speed, wind direction, wave height, and glare), observer characteristics (e.g., experience, fatigue, and concentration), and platform characteristics (e.g., pitch, roll, speed, and height above water). To derive estimates of perception bias, typically an independent observer is present who looks for marine mammals missed by the primary observers. Mark-recapture methods are then used to estimate the probability that animals are missed by the primary observers. Availability bias accounts for animals that are missed because they are not at the surface at the time the survey platform passes by, which generally occurs more often with deep diving whales (e.g., sperm whale and beaked whale). The availability bias portion of g(0) is independent of prior marine mammal detection experience since it only reflects the probability of an animal being at the surface within the survey track and therefore available for detection.

Some g(0) values are estimates of perception bias only, some are estimates of availability bias only, and some reflect both, depending on the species and data that are currently available. The Navy used g(0) values with both perception and availability bias components, if those data were available. If both components were not available for a particular species, the Navy determined that g(0) values reflecting perception bias or availability bias, but not both, still represent the best statistically-derived factor for assessing the likelihood of marine mammal detection by Navy Lookouts.

As noted above, line-transect surveys and subsequent analyses are typically used to estimate cetacean abundance. To systematically sample portions of an ocean area (such as the coastal waters off California or the east coast), marine mammal surveys are designed to uniformly cover the survey area and are conducted at a constant speed (generally 10 knots for ships and 100 knots for aircraft). Survey transect lines typically follow a pattern of straight lines or grids. Generally there are two primary observers searching for marine mammals. Each primary observer looks for marine mammals in the forward 90-degree quadrant on their side of the survey platform. Based on data collected during the survey, scientists determine the factors that affected the detection of an animal or group of animals directly along the transect line.

Visual marine mammal surveys (used to derive g(0)) are conducted during daylight.[5] Marine mammal surveys are typically scheduled for a season when weather at sea is more likely to be good, however, observers on marine mammal surveys will generally collect data in sea state conditions up to Beaufort 6 and do encounter rain and fog at sea which may also reduce marine mammal detections (see Barlow 2006). For most species, g(0) values are based on the detection probability in conditions from Beaufort 0 to Beaufort 5, which reflects the fact that marine mammal surveys are often conducted in less than ideal conditions (see Barlow 2003; Barlow and Forney 2007). The ability to detect some species (e.g., beaked whales, *Kogia* spp., and Dall's porpoise) decreases dramatically with increasing sea states, so g(0) estimates for these species are usually restricted to observations in sea state conditions of Beaufort 0 to 2 (Barlow 2003).

Military training and testing events differ from systematic line-transect marine mammal surveys in several respects. These differences suggest the use of g(0), as a sightability factor to quantitatively adjust model-predicted effects based on mitigation, is likely to result in an underestimate of the protection afforded by the implementation of mitigation as follows:

- Mitigation zones for military training and testing events are significantly smaller (typically less than 1,000 yd. radius) than the area typically searched during line-transect surveys, which includes the maximum viewable distance out to the horizon.
- In some cases, training and testing events can involve more than one vessel or aircraft (or both) operating in proximity to each other or otherwise covering the same general area. Additional vessels and aircraft can result in additional watch personnel observing the mitigation zone (e.g., ship shock trials). This would result in more observation platforms and observers looking at the mitigation zone than the two primary observers used in marine mammal surveys upon which g(0) is based.
- A systematic marine mammal line-transect survey is designed to sample broad areas of the ocean, and generally does not retrace the same area during a given survey. Therefore, in terms of g(0), the two primary observers have only a limited opportunity to detect marine mammals that may be present during a single pass along the trackline (i.e., deep diving species may not be present at the surface as the survey transits the area). In contrast, many military training and

[5] At night, passive acoustic data may still be collected during a marine mammal survey.

testing activities involve area-focused events (e.g., anti-submarine warfare tracking exercise), where participants are likely to remain in the same general area during an event. In other cases military training or testing activities are stationary (i.e., pierside sonar testing or use of dipping sonar), which allow Lookouts to focus on the same area throughout the activity. Both of these circumstances result in a longer observation period of a focused area with more opportunities for detecting marine mammals, than are offered by a systematic marine mammal line-transect survey that only passes through an area once.

Although Navy Lookouts on ships have hand-held binoculars and on some ships, pedestal mounted binoculars very similar to those used in marine mammal surveys, there are differences between the scope and purpose of marine mammal detections during research surveys along a trackline and Navy Lookouts observing the water proximate to a military training or testing activity to facilitate implementation of mitigation. The distinctions required careful consideration when comparing the Navy Lookouts to marine mammal surveys.[6]

- A marine mammal observer is responsible for detecting marine mammals in their quadrant of the trackline out to the limit of the available optics. Although Navy Lookouts are responsible for observing the water for safety of ships and aircraft, during specific training and testing activities, they need only detect marine mammals in the relatively small area that surrounds the mitigation zone (in most cases less than 1,000 yd. from the ship) for mitigation to be implemented.
- Navy Lookouts, personnel aboard aircraft and on watch onboard vessels at the surface will have less experience detecting marine mammals than marine mammal observers used for line-transit survey. However, Navy personnel responsible for observing the water for safety of ships and aircraft do have significant experience looking for objects (including marine mammals) on the water's surface and Lookouts are trained using the NMFS-approved Marine Species Awareness Training.

[6] Barlow and Gisiner (2006) provide a description of typical marine mammal survey methods from ship and aircraft and then provide "a crude estimate" of the difference in detection of beaked whales between trained marine mammal observers and seismic survey mitigation, which is not informative with regard to Navy mitigation procedures for the following reasons. The authors note that seismic survey differs from marine mammal surveys in that, "(1) seismic surveys are also conducted at night; (2) seismic surveys are not limited to calm sea conditions; (3) mitigation observers are primarily searching with unaided eyes and 7x binoculars; and (4) typically only one or possibly two observers are searching." When Navy implements mitigation for which adjustments to modeling output were made, the four conditions Barlow and Gisiner (2006) note are not representative of Navy procedures nor necessarily a difference in marine mammal line-transect survey procedures. Navy accounts for reduced visibility (i.e., activities which occur at night, etc.) by assigning a lower value to the mitigation effectiveness factor. On Navy ships, hand-held binoculars are always available and pedestal mounted binoculars very similar to those used in marine mammal surveys, are generally available to Navy Lookouts on board vessels over 60 ft. Also like marine mammal observers, Navy Lookouts are trained to use a methodical combination of unaided eye and optics as they search the surface around a vessel. The implication that marine mammal surveys only occur in "calm sea conditions" is not accurate since the vast majority of marine mammal surveys occur and data is collected in conditions up to sea states of Beaufort 5. The specific g(0) values analyzed by Barlow and Gisiner (2006) were derived from survey data for Cuvier's and *Mesoplondon* beaked whales conducted that were detected in sea states of Beaufort 0–2 during daylight hours which, as noted above, is common for marine mammal surveys conducted for these particular species. However, marine mammal surveys for most species are not similarly restricted to sea states of Beaufort 0–2, many species g(0) values are based on conditions up to and including Beaufort 5 and, therefore, the conclusions reached by Barlow and Gisiner (2006) regarding the effect of sea state conditions on sightability do not apply to other species. Finally, when Lookouts are present, there are always more than the "one or two personnel" described by Barlow and Gisiner (2006) observing the area ahead of a Navy vessel (additional bridge watch personnel are also observing the water around the vessel).

Although there are distinct differences between marine mammal surveys and military training and testing, the use of g(0) as an approximate sightability factor for quantitatively adjusting model-predicted impacts due to mitigation [mitigation effectiveness x g(0)] is an appropriate use of the best available science based on the way it has been applied. I'Conservative application of g(0) includes:

- In addition to a sightability factor (based on g(0)), the Navy also applied a mitigation effectiveness factor to acknowledge the uncertainty associated with applying the g(0) values derived from marine mammal surveys to specific military training and testing activities where the ability to observe the whole mitigation zone is less than optimal (generally due to the size of the mitigation zone).
- For activities that can be conducted at night, the Navy assigned a lower value to the mitigation effectiveness factor. For example, if an activity can take place at night half the time, then the mitigation effectiveness factor was only given a value of 0.5.
- The Navy did not quantitatively adjust model-predicted effects for activities that were given a mitigation effectiveness factor of zero. A mitigation effectiveness factor of zero was given to activities where less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone. In reality, however, some protection from applied mitigation measures would be afforded even during these activities, even though it is not accounted for in the quantitative reduction of model-predicted impacts.
- The Navy did not quantitatively adjust model-predicted effects based on detections made by other personnel that may be involved with an event (such as range support personnel aboard a torpedo retrieval boat or support aircraft), even though in reality information about marine mammal sightings are shared amongst the units participating in the training or testing activity. In other words, the Navy only quantitatively adjusted the model-predicted effects based on the required number of Lookouts.
- The Navy only quantitatively adjusted model-predicted effects within the range to mortality (explosives only) and injury (all sound-producing activities), and not for the range to TTS or other behavioral effects (see Table 5.3-2 for a comparison of the range to effects for PTS, TTS, and the recommended mitigation zone). Despite employing the required mitigation measures during an activity that will also reduce some TTS exposures, Navy did not quantitatively adjust the model-predicted TTS effects as a result of implemented mitigation.
- The total model-predicted number of animals affected is not reduced by the post-model mitigation analysis, since all reductions in mortality and injury effects are then added to and counted as TTS effects.
- Mitigation involving a power-down or cessation of sonar, or delay in use of explosives, as a result of a marine mammal detection, protects the observed animal and all unobserved (below the surface) animals in the vicinity. The quantitative adjustments of model-predicted impacts, however, assumes that only animals on the water surface, approximated by considering the species-specific g(0) and activity-specific mitigation effectiveness factor, would be protected by the applied mitigation (i.e., a power down or cessation of sonar or delaying the event). The quantitative post-model mitigation analysis, therefore, does not capture the protection afforded to all marine mammals that may be near or within the mitigation zone.

The Navy recognizes that g(0) values are estimated specifically for line-transect analyses; however, g(0) is still the best statistically-derived factor for assessing the likely marine mammal detection abilities of Navy Lookouts. Based on the points summarized above, as a factor used in accounting for the implementation of mitigation, g(0) is therefore considered to be the best available scientific basis for Navy's representation of the sightability of a marine mammal as used in this analysis.

The g(0) value used in the mitigation analysis is based on the platform(s) with Lookouts utilized in the activity. In the case of multiple platforms, the higher g(0) value for either the aerial or vessel platform is selected. For species for which there is only a single published value for each platform, that individual value is used. For species for which there is a range of published g(0) values, an average of the values, calculated separately for each platform, is used. A g(0) of zero is assigned to species for which there are no data available, unless a g(0) estimate can be extrapolated from similar species/guilds based on the published g(0) values. The g(0) values used in this analysis are provided in Table 3.4-8. The post-model acoustic effects quantification process is summarized in Table 3.4-9.

Table 3.4-8: Sightability Based on g(0) Values for Marine Mammal Species in the Study Area

Species/Stocks	Family	Vessel Sightability	Aircraft Sightability
Blainville's Beaked Whale	Ziphidae	0.395	0.074
Blue Whale, Fin Whale; Omura's Whale; Sei Whale	Balaenopteridae	0.921	0.407
Bottlenose Dolphin, Fraser's Dolphin	Delphinidae	0.808	0.96
Bryde's Whale	Balaenopteridae	0.91	0.407
Cuvier's Beaked Whale; Ginkgo-toothed Beaked Whale	Ziphidae	0.23	0.074
Dwarf Sperm Whale, Pygmy Sperm Whale, *Kogia* spp.	Kogiidae	0.35	0.074
False Killer Whale, Melon-headed Whale	Delphinidae	0.76	0.96
Humpback Whale	Balaenopteridae	0.921	0.495
Killer Whale	Delphinidae	0.91	0.96
Longman's Beaked Whale, Pygmy Killer Whale	Ziphidae, Delphinidae	0.76	0.074
Mesoplodon spp.	Ziphiidae	0.34	0.11
Minke Whale	Balaenopteridae	0.856	0.386
Pantropical Spotted/Risso's/Rough-toothed/ Spinner/Striped Dolphin	Delphinidae	0.76	0.96
Short-finned Pilot Whale	Delphinidae	0.76	0.96
Sperm Whale	Physeteridae	0.87	0.495

Note: For species having no data, the g(0) for Cuvier's aircraft value (where g(0) = 0.074) was used; or in cases where there was no value for vessels, the g(0) for aircraft was used as a conservative underestimate of sightability following the assumption that the availability bias from a slower moving vessel should result in a higher g(0).

Sources: Barlow 2010; Barlow and Forney 2007; Carretta et al. 2000.

Table 3.4-9: Post-Model Acoustic Impact Analysis Process

What is the Sound Source? Sonar (or Other Active Sources) OR Explosives?	
Sonar and Other Active Acoustic Sources (i.e., Non-impulse Sources)	**Explosives (i.e., Impulse Sources)**
S-1. Is the activity preceded by multiple vessel activity or hovering helicopter?	**E-1. Is the activity preceded by multiple vessel activity or hovering helicopter?**
Species sensitive to human activity (e.g., beaked whales) are assumed to avoid the activity area, putting them out of the range to Level A harassment. Model-estimated permanent threshold shift (PTS) exposures to these species during these activities are unlikely to actually occur and, therefore, are considered to be temporary threshold shift (TTS) exposures (animal is assumed to move into the range of TTS). The training and testing activities that are preceded by multiple vessel movements or hovering helicopters are listed in Table 3.4-14 and Table 3.4-15 in Section 3.4.4.1.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources).	Species sensitive to human activity (e.g., beaked whales) are assumed to avoid the activity area, putting them out of the range to mortality. Model-estimated mortalities to these species during these activities are unlikely to actually occur and, therefore, are considered to be injuries (animal is assumed to move into the range of potential injury). The training and testing activities that are preceded by multiple vessel movements or hovering helicopters are listed in Table 3.4-20 in Section 3.4.4.2.2 (Avoidance Behavior and Mitigation Measures as Applied to Explosions).
S-2. Can Lookouts observe the activity-specific mitigation zone (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) up to and during the sound-producing activity?	**E-2. Can Lookouts observe the activity-specific mitigation zone (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) up to and during the sound-producing activity?**
If Lookouts are able to observe the mitigation zone up to and during a sound-producing activity, the sound-producing activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone (per the mitigation procedures in Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). Therefore, model-estimated PTS exposures are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated PTS exposures are instead assumed to be TTS (animal is assumed to move into the range of TTS). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated Lookout(s). For activities with Lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 3.4-8. The Mitigation Effectiveness values are provided in Table 3.4-16.	If Lookouts are able to observe the mitigation zone up to and during an explosion, the explosive activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone. Therefore, model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated mortalities or injuries are instead assumed to be injuries or behavioral disturbances, respectively (animals are assumed to move into the range of a lower effect). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated Lookout(s). For activities with Lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 3.4-8. The Mitigation Effectiveness values for explosive activities are provided in Table 3.4-21.

Table 3.4-9: Post-Model Acoustic Impact Analysis Process (continued)

S-3. Does the activity cause repeated sound exposures which an animal would likely avoid?	E-3. Does the activity cause repeated sound exposures which an animal would likely avoid?
The Navy Acoustic Effects Model assumes that animals do not move away from a sound source and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the sound source. Therefore, only the initial exposures resulting in model-estimated PTS exposures to high-frequency cetaceans, low-frequency cetaceans, and phocids are expected to actually occur (after accounting for mitigation in step S-3). Model estimates of PTS exposures beyond the initial pings are considered to actually be behavioral disturbances, as the animal is assumed to move out of the range to PTS and into the range of TTS. Marine mammals in the mid-frequency hearing group would have to be close to the most powerful moving source (less than 10.9 yards [10 meters]) to experience PTS. These model-estimated PTS exposures of mid-frequency cetaceans are unlikely to actually occur and, therefore, are considered to be TTS (animal is assumed to move into the range of TTS).	The Navy Acoustic Effects Model assumes that animals do not move away from multiple explosions and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the site of multiple explosions. Therefore, only the initial exposures resulting in model-estimated PTS exposures are expected to actually occur (after accounting for mitigation in step E-2). Model estimates of PTS are reduced to account for animals moving away from an area with multiple explosions, out of the range to PTS, and into the range of TTS. Activities with multiple explosions are listed in Section 3.4.4.2.2 (Avoidance Behavior and Mitigation Measures as Applied to Explosions) Table 3.4-22.

Note: For additional information on post-modeling analysis refer to the Navy's Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for the Mariana Islands Training and Testing technical report (U.S. Department of the Navy 2013d).

3.4.3.4 Marine Mammal Monitoring During Training and Testing

The current behavioral exposure criteria under the response function also assumes there will be a range of reactions from minor or inconsequential to severe. Section 3.0.2.2 (Navy Integrated Comprehensive Monitoring Program) summarizes the monitoring data that have been collected thus far within the Study Area. For further discussion, also see Section 3.4.5.2 (Summary of Observations During Previous Navy Activities). Results of monitoring may provide indications that the severity of reactions suggested by the current modeling and thresholds has been overestimated.

3.4.3.5 Application of the Marine Mammal Protection Act to Potential Acoustic and Explosive Effects

The MMPA prohibits the unauthorized harassment of marine mammals and provides the regulatory processes for authorization for any such incidental harassment that might occur during an otherwise lawful activity. Harassment that may result from military training and testing activities described in this EIS/OEIS is unintentional and incidental to those activities.

For military readiness activities, MMPA Level A harassment includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. Injury, as defined in this EIS/OEIS, is the destruction or loss of biological tissue from a marine mammal. The destruction or loss of biological tissue will result in an alteration of physiological function that exceeds the normal daily physiological variation of the intact tissue. For example, increased localized histamine production, edema, production of scar tissue, activation of clotting factors, white blood cell response, etc., may be expected following injury. Therefore, this EIS/OEIS assumes that all injury is qualified as a physiological effect and, to be consistent with prior actions and rulings (National Marine Fisheries Service 2001, 2009 a, b), all injuries (except those serious enough to be expected to result in mortality) are considered MMPA Level A harassment.

PTS is non-recoverable and, by definition, results from the irreversible impacts to auditory sensory cells, supporting tissues, or neural structures within the auditory system. PTS therefore qualifies as an injury and is classified as Level A harassment under the wording of the MMPA. The smallest amount of PTS (onset-PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with onset-PTS is used to define the outer limit of the MMPA Level A exposure zone. Model-predicted slight lung injury, gastrointestinal tract injuries, and mortalities are also considered MMPA Level A harassment in this analysis.

Public Law 108-136 (2004) amended the MMPA definitions of Level B harassment for military readiness activities to be “any act that disturbs or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered.” Unlike MMPA Level A harassment, which is solely associated with physiological effects, both physiological and behavioral effects may cause MMPA Level B harassment.

TTS is recoverable and is considered to result from the temporary, non-injurious fatigue of hearing-related tissues. The smallest measurable amount of TTS (onset-TTS) is taken as the best indicator for slight temporary sensory impairment. Because it is considered non-injurious, the acoustic exposure associated with onset-TTS is used to define the outer limit of the portion of the MMPA Level B exposure zone attributable to physiological effects. Short-term reduction in hearing acuity could be considered a temporary decrement similar in scope to a period of hearing masking or behavioral disturbance. As such, it is considered by the Navy and NMFS as a Level B effect overlapping the range of sounds producing behavioral effects.

The harassment status of slight behavior disruption has been addressed in workshops, previous actions, and rulings (National Marine Fisheries Service 2001, 2008b, 2009a, 2009b; U.S. Department of Defense 2001). The conclusion is that a momentary behavioral reaction of an animal to a brief, time-isolated acoustic event does not qualify as MMPA Level B harassment. This analysis uses behavioral criteria to predict the number of animals likely to experience a significant behavioral reaction, and therefore a MMPA Level B harassment.

NMFS also includes mortality, or serious injury likely to result in mortality, as a possible outcome to consider in addition to MMPA Level A and MMPA Level B harassment. An individual animal predicted to experience simultaneous multiple injuries, multiple disruptions, or both, is typically counted as a single take (National Marine Fisheries Service 2001, 2006). There are many possible temporal and spatial combinations of activities, stressors, and responses, for which multiple reasonable methods can be used to quantify take by Level B harassment on a case-specific basis. NMFS generally considers it appropriate for applicants to consider multiple modeled exposures of an individual animal to levels above the behavioral harassment threshold within one 24-hour period as a single MMPA take. Behavioral harassment, under the response function presented in this request, uses received sound pressure level over a 24-hour period as the metric for determining the probability of harassment (see Section 3.4.4.1.2, Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources).

3.4.3.6 Application of the Endangered Species Act to Marine Mammals

Generalized information on definitions and the application of the ESA are presented in Section 3.0.4 (Acoustic and Explosives Primer) along with the acoustic conceptual framework used in this analysis. Consistent with NMFS analysis for Section 7 consultation under the ESA (e.g., National Marine Fisheries Service 2013), the spatial and temporal overlap of activities with the presence of listed species is assessed in this EIS/OEIS. The definitions used by the Navy in making the determination of effect under Section 7 of the ESA are based on the U.S. Fish and Wildlife Service and NMFS *Endangered Species Consultation Handbook* (United States Fish and Wildlife Service and National Marine Fisheries Service 1998) and recent NMFS Biological Opinions involving many of the same activities and species.

- "No effect" is the appropriate conclusion when a listed species or its designated critical habitat will not be affected, either because the species will not be present or because the project does not have any elements with the potential to affect the species or modify designated critical habitat. "No effect" does not include a small effect or an effect that is unlikely to occur.
- If effects are insignificant (in size) or discountable (extremely unlikely), a "may affect" determination is still appropriate. "May affect" is appropriate when animals are within a range where they could potentially detect or otherwise be affected by the sound (e.g., the sound is above background ambient levels). If effects are insignificant (in size) or discountable (extremely unlikely), a "may affect" determination is appropriate.
    - Insignificant effects relate to the size of the impact and should never reach the scale where take occurs.
    - Discountable effects are those extremely unlikely to occur; based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.
- If a stressor and species presence overlap, and a predicted effect is not insignificant, discountable, or beneficial, a "may affect, likely to adversely affect" determination is appropriate.

There are no harassment or injury criteria established for marine mammals under the ESA because the ESA requires an assessment starting with mere exposure potential. Acoustic modeling is used to predict the number of ESA-listed marine mammals exposed to sound resulting from military training and testing activities, without any behavioral or physiological criteria applied.

There is no designated critical habitat in the MITT Study Area.

3.4.4 ANALYSIS OF EFFECTS ON MARINE MAMMALS

3.4.4.1 Impacts from Sonar and Other Active Acoustic Sources

Sonar and other active acoustic sources proposed for use are transient in most locations as active sonar activities move throughout the MITT Study Area. Sonar and other active acoustic sound sources emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of sonar systems are described in Section 3.0.4.1.6 (Classification of Acoustic and Explosive Sources).

Exposure of marine mammals to sonar and other active acoustic sources is not likely to result in primary blast injuries or barotraumas given the power output of the sources and the proximity to the source that would be required. Sonar induced acoustic resonance and bubble formation phenomena are also unlikely to occur under realistic conditions in the ocean environment, as discussed in Section 3.4.3.1.2.1 (Direct Injury). Direct injury from sonar and other active acoustic sources would not occur under conditions present in the natural environment, and therefore is not considered further in this analysis. Research and observations of auditory masking in marine mammals is discussed in Section 3.4.3.1.2.4 (Auditory Masking).

Anti-submarine warfare sonar can produce intense underwater sounds in the Study Area associated with the Proposed Action. These sounds are likely within the audible range of most cetaceans but are normally very limited in the temporal, frequency, and spatial domains. The duration of individual sounds is short; sonar pulses can last up to a few seconds each, but most are shorter than 1 second. The duty cycle is low, with most tactical anti-submarine warfare sonar typically transmitting about once per minute. Furthermore, events are geographically and temporally dispersed, and most events are limited to a few hours. Tactical sonar has a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood of sources causing significant auditory masking in marine mammals.

Some object-detecting sonar (i.e., mine warfare sonar) has a high duty cycle producing up to a few pings per second. Such sonar typically employs high frequencies (above 10 kHz) that attenuate rapidly in the water, thus producing only a small area of potential auditory masking. Higher-frequency mine warfare sonar systems are typically outside the hearing and vocalization ranges of mysticetes (Section 3.4.2.3, Vocalization and Hearing of Marine Mammals); therefore, mysticetes are unlikely to be able to detect the higher frequency mine warfare sonar, and these systems would not interfere with their communication or detection of biologically relevant sounds. Odontocetes may experience some limited masking at closer ranges as the frequency band of many mine warfare sonar overlaps the hearing and vocalization abilities of some odontocetes; however, the frequency band of the sonar is narrow, limiting the likelihood of auditory masking. With any of these activities, the limited duration and dispersion of the activities in space and time reduce the potential for auditory masking effects from proposed activities on marine mammals.

The most probable effects from exposure to sonar and other active acoustic sources are PTS, TTS, and behavioral harassment (Section 3.4.4.1.3, Predicted Impacts from Sonar and Other Active Acoustic Sources, and Section 3.4.3.1.2.6, Behavioral Responses). The Navy Acoustic Effects Model is used to produce initial estimates of the number of animals that may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation. These are discussed below in the following sections.

Another concern is the number of times an individual marine mammal is exposed and potentially reacts to a sonar or other active acoustic source over the course of a year or within a specific geographic area. Animals that are resident during all or part of the year near Navy ports or on fixed Navy ranges are the most likely to experience multiple exposures. Repeated and chronic noise exposures to marine mammals and their observed reactions are discussed in this analysis where applicable.

3.4.4.1.1 Range to Effects

The following section provides the predicted range (distance) over which specific physiological or behavioral effects are expected to occur based on the acoustic criteria (Finneran and Jenkins 2012) and the acoustic propagation calculations from the Navy Acoustic Effects Model (Section 3.4.3.1.5.3, Navy Acoustic Effects Model).

The range to specific effects are used to assess model results and determine adequate mitigation ranges to avoid higher level effects, especially physiological effects (e.g., PTS). Additionally, these data can be used to analyze the likelihood of an animal being able to avoid the effects of an oncoming sound source by simply moving a short distance away (e.g., a few hundred meters). Figure 3.4-6 shows a representation of effects with distance from a hypothetical sonar source; notice the proportion of animals that are likely to have a behavioral response (yellow block; "response-function") decreases with increasing distance from the source.

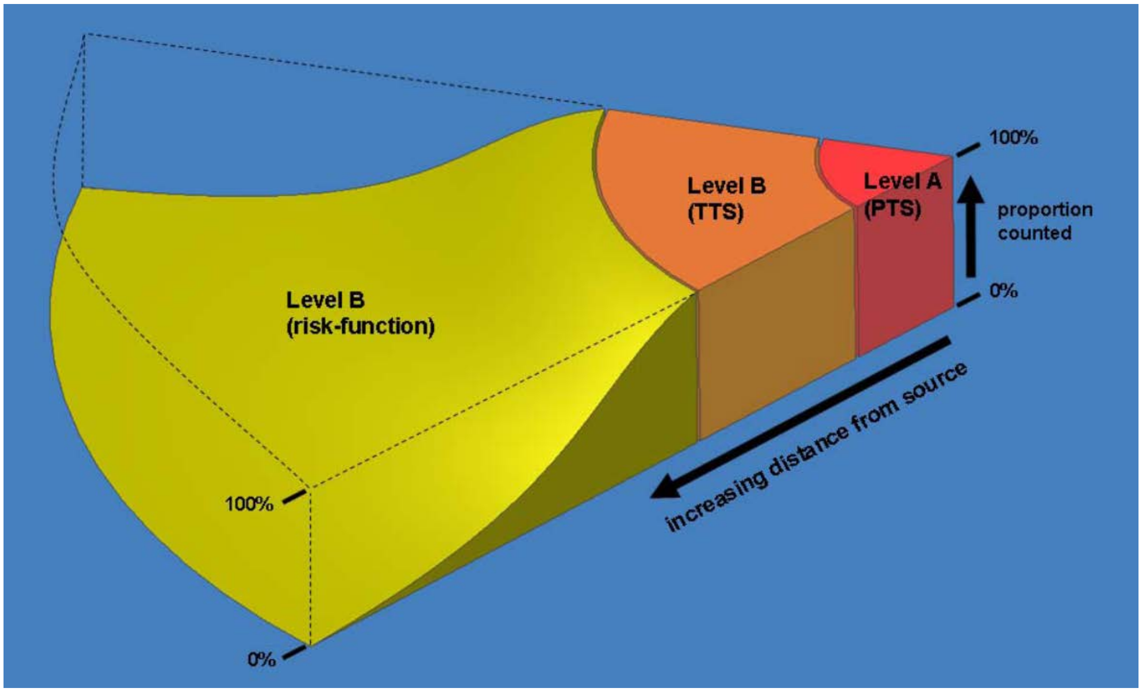

Figure 3.4-6: Hypothetical Range to Specified Effects for a Non-Impulse Source

Although the Navy uses a number of sonar and active acoustic sources, the three sonar bins provided below (MF1, MF4, and MF5) represent three of the most powerful sources (see 3.0.4.1.5, Categories of Sound, for a discussion of sonar and other active acoustic source bins included in this analysis). These three sonar bins are often the dominant source in the activity in which they are included, especially for smaller unit level training exercises and many testing activities. Therefore, these ranges provide realistic maximum distances over which the specific effects would be possible.

PTS: The ranges to the PTS threshold (i.e., ranges to onset of PTS: the maximum distance to which PTS would be expected) are shown in Table 3.4-10 relative to the marine mammal's functional hearing group (Navy's high-frequency sources have a lower source level and more energy loss over distance than these mid-frequency examples and therefore have a shorter range to effects). For SQS-53C sonar transmitting for 1 second at 3 kHz and a source level of 235 dB re 1 μPa^2-s at 1 m, the range to PTS for the most sensitive species (the high-frequency cetaceans) extends from the source to a range approximately 100 m (109 yd.).

Since any surface vessel using hull-mounted anti-submarine warfare sonar, such as the SQS-53, engaged in anti-submarine warfare training and testing would be moving at between 10 and 15 knots (5.1 and 7.7 m/second) and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 280 yd. (257 m) during the time between those pings (note: 10 knots is the speed used in the Navy Acoustic Effects Model). As a result, there is little overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). It is unlikely that any animal would receive overlapping PTS level exposures from a second ship, as Navy sonar exercises do not involve ships within such close proximity to each other while using their active sonar. For all other functional hearing groups (low-frequency cetaceans and mid-frequency cetaceans) single-ping PTS zones are within 77 yd. (70 m) of the sound source. A scenario could occur where an animal does not leave the vicinity of a ship or travels a course parallel to the ship; however, as indicated in Table 3.4-10, the distances required make a second PTS exposure unlikely. For a military vessel moving at a nominal 10 knots, it is unlikely a marine mammal could maintain the speed to parallel the ship and receive adequate energy over successive pings to result in PTS. For all sources except hull-mounted sonar (e.g., SQS-53) ranges to PTS are well within 27 yd. (25 m), even for multiple pings (up to 10 pings examined) and the most sensitive functional hearing group (high-frequency cetaceans).

Table 3.4-10: Approximate Ranges to Permanent Threshold Shift Criteria for Each Functional Hearing Group for a Single Ping from Three of the Most Powerful Sonar Systems within Representative Ocean Acoustic Environments

Functional Hearing Group	Ranges to Onset PTS for One Ping (meters)[1]		
	Source Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)	Source Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)	Source Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)
Low-Frequency Cetaceans	70	10	< 2
Mid-Frequency Cetaceans	10	< 2	< 2
High-Frequency Cetaceans	100	20	10

[1] Ranges to TTS represent the sound energy loss due to spherical spreading to reach the furthest distance to the PTS effect criteria.

Notes: ASW = anti-submarine warfare, TTS = temporary threshold shift, PTS = permanent threshold shift

TTS: Table 3.4-11 illustrates the ranges to the onset of TTS (i.e., the maximum distances to which TTS would be expected) for 1, 5, and 10 pings from four representative sonar systems. Due to the lower acoustic thresholds for TTS versus PTS, ranges to onset TTS are longer; this can also be thought of as a larger volume acoustic footprint for TTS effects. Because the effects threshold is total summed sound energy and because of the greater range to effects, successive pings can add together, further increasing the range to onset-TTS.[7]

For hull-mounted sonar (e.g., the SQS-53), mid-frequency cetaceans have TTS ranges of up to 200 yd. (180 m) for 1 ping; up to 480 yd. (440 m) for 5 pings; and up to 1,910 yd. (1,750 m) for 10 pings. For all other sonar and other active acoustic sources, the range to TTS for up to 10 pings is within 55 yd. (50 m) for mid-frequency cetaceans, making any temporary hearing loss in these species from these sources very unlikely.

[7] This discussion is presenting a simple case for an omni-directional stationary sources and stationary animals. With a moving source such as all hull mounted anti-submarine warfare sonar, the additional volume of energy above the TTS threshold is only present where there is overlap of sufficient acoustic energy from subsequent pings. When a source is moving, the time between pings and the vessel's forward motion can exceed the distance required for sufficient overlap of acoustic energy from the summation of subsequent pings and therefore never exceed the TTS (total energy) threshold. The nominal speed and time between pings for a ship engaged in anti-submarine warfare events will result in the source having traveled approximately 281–393 yd. (257–359 m) between pings. Additional factors such as animals avoiding the source, porpoising behavior, etc. are additional complexities.

Low-frequency cetaceans (mysticetes) have TTS ranges for 10 pings from anti-submarine warfare hull mounted sonar (e.g., SQS-53) of approximately 9,690 yd. (8,860 m). Ten pings from anti-submarine warfare dipping sonar (e.g., AQS-22) would produce a TTS zone of approximately 2,950 yd. (2,700 m). Ten pings from a SSQ-62 sonobuoy would have a range to onset TTS of up to 1,760 yd. (1,560 m), and 10 pings from the SSQ-32 sonar system would produce a TTS zone extending up to 900 yd. (820 m) from the source.

Ranges to TTS for high-frequency cetaceans are the most extensive of the three groups based on a low acoustic effects threshold for these apparently sensitive species. For a hull-mounted sonar (e.g., SQS-53), ranges to TTS for high-frequency cetaceans are up to 8,280 yd. (7,570 m) for 1 ping, up to 16,790 yd. (15,350 m) for 5 pings, and up to 21,325 yd. (19,500 m) for 10 pings. Ranges to onset TTS for high-frequency cetaceans are much shorter for all other systems. The range for anti-submarine warfare dipping sonar is approximately 100 yd. (90 m) for 1 ping and up to 1,040 yd. (950 m) for 10 pings. Range to onset TTS for sonobuoys and mine warfare sonar, which have lower source levels than hull-mounted and dipping sonar systems, is less than 55 yd. (50 m) for 1, 5, and 10 pings.

Behavioral: The distances at which a significant behavioral response from an animal may occur, and the percentage of animals that may exhibit a response, are estimated for four representative sonar sources using the mysticete (low-frequency cetacean) and odontocete (mid-frequency cetacean) behavioral response functions (Table 3.4-12 and Table 3.4-13, respectively).

The distance from the source and the percentage of animals that would exhibit a behavioral response at that distance are calculated for SPLs ranging from 120 dB to 198 dB re 1 μPa, with SPLs grouped into 6 dB increments. The distance from the source to a specific sound pressure level varies by sonar system. For the most powerful hull-mounted sonar systems (e.g., SQS-53) the distance from the sound source to 120 dB re 1 μPa is approximately 184 km. However, at that distance, the analysis predicts that less than 1 percent of animals would respond to the received sound level (SPLs from 120 dB to 126 dB re 1 μPa). For the AQS-22 dipping sonar, approximately 42 percent of animals located between 8,970 and 65,620 yd. (8,200 and 60,000 m) from the sound source may exhibit a behavioral response to sonar transmissions (Table 3.4-12 and Table 3.4-13). Beaked whales are predicted to have behavioral reactions at distances out to approximately 184 km (Table 3.4-13).

See Section 3.4.3.1.2 (Analysis Background and Framework) for details on the derivation and use of the behavioral response function as well as the step function threshold used for beaked whales of 140 dB re 1 μPa.

Table 3.4-11: Approximate Ranges to Onset of Temporary Threshold Shift for Four Representative Sonar Over a Representative Range of Ocean Environments

Functional Hearing Group	Approximate Ranges to the Onset of TTS (meters)[1]											
	Source Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)			Source Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)			Source Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)			Sonar Bin HF4 (e.g., SQQ-32; MIW Sonar)		
	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings
Low-Frequency Cetaceans	560–2,280	1,230–6,250	1,620–8,860	220–240	490–1,910	750–2,700	110–120	240–310	340–1,560	100–160	150–730	150–820
Mid-Frequency Cetaceans	150–180	340–440	510–1,750	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
High-Frequency Cetaceans	2,170–7,570	4,050–15,350	5,430–19,500	90	180–190	260–950	< 50	< 50	< 50	< 50	< 50	< 50

[1] Ranges to TTS represent the model-predicted zones in which animals are expected to receive TTS and extends from onset-PTS to the distance indicated.

Notes: ASW = anti-submarine warfare, MIW = mine warfare, TTS = temporary threshold shift

Table 3.4-12: Range to Received Sound Pressure Level in 6-Decibel Increments and Percentage of Behavioral Harassments for Low-Frequency Cetaceans under the Mysticete Behavioral Response Function for Four Representative Source Bins (Nominal Values; Not Specific to the Study Area)

Received Level in 6dB Increments	Source Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)		Source Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)		Source Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		Source Bin HF4 (e.g., SQQ-32; MIW Sonar)	
	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment
120 <= SPL < 126	183,000–133,000	< 1%	71,000–65,000	< 1%	18,000–13,000	< 1%	2,300–1,700	< 1%
126 <= SPL < 132	133,000–126,000	<1%	65,000–60,000	< 1%	13,000–7,600	< 1%	1,700–1,200	< 1%
132 <= SPL < 138	126,000–73,000	< 1%	60,000–8,200	42%	7,600–2,800	12%	1,200–750	< 1%
138 <= SPL < 144	73,000–67,000	< 1%	8,200–3,500	10%	2,800–900	26%	750–500	5%
144 <= SPL < 150	67,000–61,000	3%	3,500–1,800	12%	900–500	15%	500–300	17%
150 <= SPL < 156	61,000–17,000	68%	1,800–950	15%	500–250	21%	300–150	34%
156 <= SPL < 162	17,000–10,200	12%	950–450	13%	250–100	20%	150–100	20%
162 <= SPL < 168	10,200–5,600	9%	450–200	6%	100–<50	6%	100–< 50	24%
168 <= SPL < 174	5,600–1,600	6%	200–100	2%	< 50	< 1%	< 50	< 1%
174 <= SPL < 180	1,600–800	< 1%	100–< 50	< 1%	< 50	< 1%	< 50	< 1%
180 <= SPL < 186	800–400	< 1%	<50	< 1%	< 50	< 1%	< 50	< 1%
186 <= SPL < 192	400–200	< 1%	<50	< 1%	< 50	< 1%	< 50	< 1%
192 <= SPL < 198	200–100	< 1%	<50	< 1%	< 50	< 1%	< 50	< 1%

Notes: ASW = anti-submarine warfare, MIW = mine warfare, m = meters, SPL = sound pressure level

Table 3.4-13: Range to Received Sound Pressure Level in 6-Decibel Increments and Percentage of Behavioral Harassments for Mid-Frequency Cetaceans under the Odontocete Behavioral Response Function for Four Representative Source Bins (Nominal Values for Deep Water Offshore Areas; Not Specific to the Study Area)

Received Level in 6dB Increments	Source Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)		Source Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)		Source Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		Source Bin HF4 (e.g., SQQ-32; MIW Sonar)	
	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment
120 <= SPL < 126	184,000–133,000	< 1%	72,000–66,000	< 1%	19,000–15,000	< 1%	3,600–2,800	< 1%
126 <= SPL < 132	133,000–126,000	< 1%	66,000–60,000	< 1%	15,000–8,500	< 1%	2,800–2,100	< 1%
132 <= SPL < 138	126,000–73,000	< 1%	60,00–8,300	41%	8,500–3,300	3%	2,100–1,500	< 1%
138 <= SPL < 144	73,000–67,000	< 1%	8,300–3,600	10%	3,300–1,000	12%	1,500–1,000	3%
144 <= SPL < 150	67,000–61,000	3%	3,600–1,900	12%	1,000–500	10%	1,000–700	10%
150 <= SPL < 156	61,000–18,000	68%	1,900–950	15%	500–300	22%	700–450	21%
156 <= SPL < 162	18,000–10,300	13%	950–480	12%	300–150	27%	450–250	32%
162 <= SPL < 168	10,300–5,700	9%	480–200	7%	150–< 50	25%	250–150	19%
168 <= SPL < 174	5,700–1,700	6%	200–100	2%	< 50	< 1%	150–100	9%
174 <= SPL < 180	1,700–900	< 1%	100–< 50	< 1%	< 50	< 1%	100–< 50	6%
180 <= SPL < 186	900–400	< 1%	< 50	< 1%	< 50	< 1%	< 50	< 1%
186 <= SPL < 192	400–200	< 1%	< 50	< 1%	< 50	< 1%	< 50	< 1%
192 <= SPL < 198	200–100	< 1%	< 50	< 1%	< 50	< 1%	< 50	< 1%

Notes: (1) ASW = anti-submarine warfare, MIW = mine warfare, m = meters, SPL = sound pressure level; (2) Odontocete behavioral response function is also used for high-frequency cetaceans.

3.4.4.1.2 Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources

As previously discussed, within the Navy Acoustic Effects Model, animats (representing individual marine mammals) do not move horizontally or react in any way to avoid sound or any other disturbance. A number of researchers have demonstrated that cetaceans can perceive the movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement, often at distances of a kilometer or more (Au and Perryman 1982; Jansen et al. 2010; Palka and Hammond 2001; Richardson et al. 1995; Tyack et al. 2011; Watkins 1986; Würsig et al. 1998; Tyack 2009). See Section 3.4.3.1.2.6 (Behavioral Responses), for a review of research and observations of marine mammals' reactions to vessels and active sound sources. The behavioral criteria used as a part of this analysis acknowledges that a behavioral reaction is likely to occur at levels below those required to cause hearing loss (TTS or PTS) or higher order physiological impacts. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area immediately around intense activity associated with a sound source (such as a low hovering helicopter) or a sound source is assumed in most cases. However, it is possible that an animal could be surprised prior to the implementation of mitigation measures (e.g., the animal is at depth and not visible at the surface). Under this scenario, the animal could receive enough acoustic energy to be exposed at the PTS level. In most cases, avoidance of the area as described above is the more likely scenario. Table 3.4-14 and Table 3.4-15 present a list of activities using sonar and other active acoustic sources that are preceded by intense activity, resulting in likely avoidance of the local area. Additionally, the Navy Acoustic Effects Model does not account for the implementation of mitigation, which would prevent many of the model-estimated PTS effects. Therefore, the model-estimated PTS effects due to sonar and other active acoustic sources are further analyzed considering avoidance and implementation of mitigation measures described in Section 3.4.3.1.5 (Quantitative Analysis) and in greater detail in the Navy's *Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for the Atlantic Fleet Training and Testing* technical report (U.S. Department of the Navy 2013d).

For example, if sound-producing activities are preceded by multiple vessel traffic or hovering aircraft, beaked whales are assumed to move beyond the range to PTS before sound transmission begins, as discussed above in Section 3.4.3.2.1 (Avoidance of Human Activity). Table 3.4-10 shows the ranges to PTS for four of the most common and three of the most powerful sound sources proposed for use when training and testing in the Study Area. The source class Bin MF1 includes the most powerful anti-submarine warfare system for a surface combatant, the SQS-53. The range to PTS for all systems is much less than 110 yd. (100 m), with the exception of high-frequency cetaceans exposed to bin MF1 with a PTS range of approximately 110 yd. (100 m). Because the Navy Acoustic Effects Model does not include avoidance behavior, the preliminary model-estimated effects are based on unlikely behavior for these species: that they would tolerate staying in an area of high human activity.

Table 3.4-14: Training Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters

Training
Fleet Strike Group Exercise
Integrated Anti-Submarine Warfare Exercise
Joint Expeditionary Exercise
Joint Multi-Strike Group Exercise
Marine Air Ground Task Force Exercise (Amphibious)
Civilian Port Defense
Mine Countermeasure – Towed Mine Detection
Mine Countermeasure Exercise – Ship Sonar
Mine Countermeasure Exercise (MCM) – Towed Sonar
Ship Squadron Anti-Submarine Warfare Exercise
TRACKEX/TORPEX – Helo

Notes: Helo = helicopter, MCM = mine countermeasure, TORPEX = torpedo exercise, TRACKEX = tracking exercise

Table 3.4-15: Testing Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters

Testing
Countermeasure Testing
ASW Mission Package Testing
MCM Mission Package Testing
Torpedo Testing

Notes: ASW = anti-submarine warfare, MCM = mine countermeasure

Animal avoidance of the area immediately around the sonar or other active acoustic system, coupled with mitigation measures designed to avoid exposing animals to high energy levels, would make the majority of model-estimated PTS to mid-frequency cetaceans unlikely. The maximum ranges to onset PTS for mid-frequency cetaceans (Table 3.4-10) do not exceed 10 yd. (10 m) in any environment modeled for the most powerful non-impulse acoustic sources, hull-mounted sonar (e.g., Bin MF1; SQS-53C). Ranges to PTS for low-frequency cetaceans and high-frequency cetaceans (Table 3.4-10) do not exceed 77 and 110 yd. (70 m and 100 m), respectively. Considering vessel speed during anti-submarine warfare activities normally exceeds 10 knots, and sonar pings occur about every 50 seconds, even for the MF1 an animal would have to maintain a position within a 22 yd. (20 m) radius in front of, or alongside the moving the ship for over 3 minutes (the time between five pings) to experience PTS. In addition, the animal(s) or pod would have to remain unobserved, otherwise implemented mitigation would result in the sonar transmissions being shut down and thus ending any further exposure. Finally, the majority of marine mammals (odontocetes) have been demonstrated to have directional hearing, with best hearing sensitivity when facing a sound source (Mooney et al. 2008; Popov and Supin 2009; Kastelein et al. 2005). An odontocete avoiding a source would receive sounds along a less sensitive hearing orientation (its tail pointed toward the source), potentially reducing impacts. All model-estimated PTS exposures of mid-frequency cetaceans, therefore, are considered to actually be TTS due to the likelihood that an animal would be observed if it is present within the very short range to PTS effects.

As part of the modeling adjustments, beaked whales that were model-estimated to experience PTS due to sonar and other active acoustic sources are assumed to move away, but conservatively considered to remain within the range of TTS prior to the start of the sound-producing activity for the activities using the sources listed in Table 3.4-14. Given the proximity to the source required for model-estimated PTS to mid-frequency cetaceans and likely avoidance of the source's vicinity, all model-estimated PTS to mid-frequency cetaceans are adjusted to TTS due to the likelihood that an animal would avoid the very short range to PTS effects (while remaining undetected). Marine mammals in other functional hearing groups, if present but not observed by Lookouts, are assumed to leave the area near the sound source after the first 3–4 pings, thereby reducing sound exposure levels and the potential for PTS. The range to the onset of PTS for low-frequency cetaceans does not exceed 77 yd. (70 m) and for high-frequency cetaceans does not exceed 110 yd. (100 m) in any environment for the most powerful active acoustic sources, hull-mounted sonar (e.g., AN/SQS-53C). As stated above, odontocetes, including high-frequency cetaceans, may also minimize sound exposure during avoidance due to directional hearing. During the first few pings of an event, or after a pause in sonar operations, if animals are caught unaware and mitigation measures are not yet implemented (e.g., animals are at depth and not visible at the surface) it is possible that they could receive enough acoustic energy resulting in PTS. Only these initial exposures resulting in model-estimated PTS are expected to actually occur. The remaining model-estimated PTS are considered to be TTS due to avoidance.

The Navy Acoustic Effects Model does not consider implemented standard mitigation measures (as presented in detail in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). To account for the implementation of mitigation measures, the acoustic effects analysis assumes a model-estimated PTS would not occur if an animal at the water surface would likely be observed during those activities with dedicated Lookouts up to and during use of the sound source, considering the sightability of a species based on g(0) (Table 3.4-8), the range to PTS for each hearing group and source (see examples on Table 3.4-10), and mitigation effectiveness (Table 3.4-16). The preliminary model-estimated PTS numbers are reduced by the portion of animals that are likely to be seen (Mitigation Adjustment Factor x Sightability). Model-predicted PTS effects are adjusted based on these factors and added to the model-predicted TTS exposures. This is a conservative approach that will still result in an overestimation of PTS effects, because the range to PTS is generally much less than 55 yd. (55 m), Lookouts need only detect animals before they are within this very close range to implement mitigation to prevent PTS, and the g(0) detection probabilities used as a sightability factor are based on having to detect animals at much greater distance (many kilometers; as presented previously in Section 3.4.3.3, Implementing Mitigation to Reduce Sound Exposures).

Table 3.4-16: Non-Impulse Activities Adjustment Factors Integrating Implementation of Mitigation into Modeling Analyses

Activity[1]	Factor for Adjustment of Preliminary Modeling Estimates[2]	Mitigation Platform Used for Assessment
Training		
Fleet Strike Group Exercise	1	Vessel
Integrated Anti-Submarine Warfare Exercise	1	Vessel
Joint Expeditionary Exercise	1	Vessel
Joint Multi-Strike Group Exercise	1	Vessel
Marine Air Ground Task Force Exercise (Amphibious)	1	Aircraft
Civilian Port Defense	1	Aircraft
Mine Countermeasure Exercise – Surface (SMCMEX) Sonar	1	Vessel
Mine Countermeasure Exercise – Towed Sonar	1	Aircraft
Mine Neutralization – Remotely Operated Vehicle Sonar	1	Vessel or Aircraft
Submarine Navigation	1	Vessel
Ship Squadron Anti-Submarine Warfare Exercise	1	Vessel
Submarine Sonar Maintenance	0.5	Vessel
Surface Ship Sonar Maintenance	1	Vessel
TRACKEX/TORPEX – MPA	0.5	Aircraft
Tracking Exercise – Maritime Patrol Advanced Extended Echo Ranging Sonobuoys	0.5	Aircraft
TRACKEX/TORPEX – Surface	0.5	Vessel
TRACKEX/TORPEX – Helo	0.5	Aircraft
Testing		
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoys)	1	Aircraft
ASW Mission Package Testing	1	Vessel
At Sea Sonar Testing	0.5	Vessel
Countermeasure Testing	1	Vessel
MCM Mission Package Testing	1	Vessel or Aircraft
Pierside Integrated Swimmer Defense	1	Vessel
Ship Signature Testing	1	Vessel
Torpedo Testing	0.5	Vessel

[1] The adjustment factor for all other activities (not listed) is zero; there is no adjustment of the preliminary modeling estimates as a result of implemented mitigation.

[2] If less than half of the mitigation zone cannot be continuously visually observed due to the type of mitigation platform used for this assessment, number of Lookouts, and size of the mitigation zone, mitigation is not used as a factor adjusting the acoustic effects analysis of that activity and the activity is not listed in this table.

Notes: MCM = mine countermeasure, MPA = maritime patrol aircraft, TORPEX = Torpedo Exercise, TRACKEX = Tracking Exercise

3.4.4.1.3 Predicted Impacts from Sonar and Other Active Acoustic Sources

Predicted impacts to marine mammals from sonar and other active acoustic sources for training and testing activities are presented for the No Action Alternative, Alternative 1, and Alternative 2 (Table 3.4-17 and Table 3.4-18). The totals presented in these tables are the summation of all proposed events occurring annually.

The Navy Acoustic Effects Model does not account for several factors (see Sections 3.0.5, Overall Approach to Analysis, and 3.4.3.2, Marine Mammal Avoidance of Sound Exposures) that must be considered in the overall acoustic analysis. The results in the following tables are the predicted exposures from the Navy Acoustic Effects Model adjusted by the animal avoidance and mitigation factors discussed in the section above (Section 3.4.4.1.2, Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources). Mitigation measures are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). These measures provide additional protections, which are not considered in the numerical results below since reductions as a result of implemented mitigation were only applied to those events having a very high likelihood of detecting marine mammals. It is important to note that there are additional protections offered by mitigation procedures that are implemented for all activities using sonar and other active acoustic sources (not just those with a high likelihood of detecting marine mammals) which will further reduce exposures to marine mammals, but they are not considered in the quantitative adjustment of the model-predicted effects.

These predicted effects are the result of the acoustic analysis, including acoustic effects modeling followed by consideration of animal avoidance of multiple exposures, avoidance by sensitive species of areas with a high level of activity, and Navy mitigation measures. It is important to note that exposures presented in Table 3.4-17 and Table 3.4-18 are the total number of exposures and not necessarily the number of individuals exposed. As discussed in Section 3.4.3.1.2.6 (Behavioral Responses), an animal could be predicted to receive more than one acoustic impact over the course of a year.

Table 3.4-17: Predicted Impacts from Annual Training Use of Sonar and Other Active Acoustic Sources

Species	No Action Alternative			Alternative 1			Alternative 2		
	Non-TTS	TTS	PTS	Non-TTS	TTS	PTS	Non-TTS	TTS	PTS
Humpback whale	223	501	0	163	609	0	218	906	0
Blue whale	4	18	0	3	22	0	5	39	0
Fin whale	5	17	0	4	22	0	6	38	0
Sei whale	73	174	0	54	229	0	71	330	0
Bryde's whale	100	212	0	71	283	0	100	439	0
Minke whale	23	67	0	18	66	0	22	94	0
Omura's whale	24	60	0	17	70	0	21	92	0
Sperm whale	503	4	0	413	23	0	610	30	0
Pygmy sperm whale	111	3,825	6	98	4,708	12	116	7,076	16
Dwarf sperm whale	298	10,167	18	276	12,034	34	326	18,166	43
Killer whale	78	5	0	62	11	0	93	15	0
False killer whale	538	29	0	421	75	0	640	97	0
Pygmy killer whale	89	6	0	79	14	0	111	17	0
Short-finned pilot whale	1,713	102	0	1,367	256	0	2,065	320	0
Melon-headed whale	2,107	153	0	1,524	365	0	2,398	462	0
Bottlenose dolphin	684	58	0	548	122	0	819	149	0
Pantropical spotted dolphin	12,468	804	0	9,612	2,128	0	13,911	2,610	0
Striped dolphin	3,328	192	0	2,482	495	0	3,668	651	0
Spinner dolphin	502	32	0	419	84	0	579	103	0
Rough-toothed dolphin	1,702	129	0	1,333	307	0	2,048	389	0
Fraser's dolphin	2,472	139	0	1,895	353	0	3,372	462	0
Risso's dolphin	462	25	0	390	65	0	577	84	0
Cuvier's beaked whale	21,968	48	0	18,563	180	0	26,394	240	0
Blainville's beaked whale	4,233	15	0	3,662	49	0	5,135	63	0
Longman's beaked whale	1,719	5	0	1,649	19	0	2,050	23	0
Ginkgo-toothed beaked whale	3,981	11	0	3,208	41	0	4,315	51	0
Total Exposures	**59,408**	**16,798**	**24**	**48,331**	**22,630**	**46**	**69,670**	**32,946**	**59**

Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 3.4-18: Predicted Impacts from Annual Testing Use of Sonar and Other Active Acoustic Sources

Species	No Action Alternative			Alternative 1			Alternative 2		
	Non-TTS	TTS	PTS	Non-TTS	TTS	PTS	Non-TTS	TTS	PTS
Humpback whale	0	0	0	18	70	0	21	86	0
Blue whale	0	0	0	0	3	0	1	4	0
Fin whale	0	0	0	0	2	0	1	3	0
Sei whale	0	0	0	7	29	0	8	35	0
Bryde's whale	0	0	0	8	36	0	10	44	0
Minke whale	0	0	0	2	15	0	2	18	0
Omura's whale	0	0	0	2	14	0	2	18	0
Sperm whale	0	0	0	39	31	0	45	46	0
Pygmy sperm whale	0	0	0	11	758	3	13	917	4
Dwarf sperm whale	0	0	0	28	1,864	7	32	2,254	10
Killer whale	0	0	0	7	4	0	8	6	0
False killer whale	0	0	0	33	26	0	38	38	0
Pygmy killer whale	0	0	0	7	5	0	8	7	0
Short-finned pilot whale	0	0	0	114	78	0	130	113	0
Melon-headed whale	0	0	0	113	83	0	129	122	0
Bottlenose dolphin	0	0	0	43	28	0	49	41	0
Pantropical spotted dolphin	0	0	0	614	456	0	705	672	0
Striped dolphin	0	0	0	204	117	0	232	173	0
Spinner dolphin	0	0	0	51	35	0	58	50	0
Rough-toothed dolphin	0	0	0	109	70	0	124	103	0
Fraser's dolphin	0	0	0	183	140	0	210	205	0
Risso's dolphin	0	0	0	31	19	0	35	28	0
Cuvier's beaked whale	0	0	0	3,670	128	0	4,171	187	0
Blainville's beaked whale	0	0	0	691	24	0	786	36	0
Longman's beaked whale	0	0	0	246	10	0	280	15	0
Ginkgo-toothed beaked whale	0	0	0	627	21	0	715	31	0
Total Exposures	**0**	**0**	**0**	**6,858**	**4,066**	**10**	**7,813**	**5,252**	**14**

Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

3.4.4.1.3.1 No Action Alternative

Training

As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1) and Section 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources), training activities under the No Action Alternative include activities that produce in-water sound from the use of sonar and other active acoustic sources. Activities could occur throughout the Study Area but would be concentrated within 200 nm of the Mariana Islands.

In excess of 61 percent of predicted effects to marine mammals from training activities under the No Action Alterative are from sonar and other active acoustic sources used during anti-submarine warfare events involving surface ships with hull-mounted sonar (i.e., tracking and torpedo exercises for surface ships), which take place more than 3 nm from shore. As discussed in Section 3.4.4.1 (Impacts from Sonar and Other Active Acoustic Sources), ranges to TTS for hull mounted sonar (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) can be on the order of several kilometers, whereas a small percentage of behavioral effects could take place at distances exceeding 184 km, more meaningful behavioral effects are much more likely at higher received levels within a few kilometers of the sound source.

Under the No Action Alternative, about 38 percent of predicted behavioral effects to marine mammals from sonar and other active acoustic sources are associated with major training exercises (i.e., Joint Expeditionary Exercise, Joint Multi-Strike Group Exercise, Marine Air Ground Task Force Exercise [Amphibious]; see Table 2.8-1). These major training exercises are multi-day events composed of multiple, dispersed activities involving multiple platforms (ships, aircraft, submarines) that often require movement across or use of large areas of a range complex. Potential acoustic impacts from major training exercises, especially behavioral impacts, could be more pronounced given the duration and scale of the activity. Some animals may be exposed to this activity multiple times over the course of a few days and leave the area temporarily; although, these activities do not use the same training locations day-after-day during multi-day activities. Therefore, displaced animals could return after the major training exercise moves away, allowing the animal to recover from any energy expenditure or missed resources.

For shorter term exposures or those from distant sources, animals may stop vocalizing, break off feeding dives, or alternatively, ignore the acoustic stimulus, especially if it is located more than a few kilometers away (see Section 3.4.3.1.2.6, Behavioral Responses, for discussion of research and observations on the behavioral reactions of marine mammals to sonar and other active acoustic sources).

In the ocean, the use of sonar and other active acoustic sources is transient and is unlikely to repeatedly expose the same population of animals over a short period. A few behavioral reactions per year, even from a single individual, are unlikely to produce long-term consequences for that individual or the population. Furthermore, mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts.

Mysticetes

Under the No Action Alternative, predicted acoustic effects to mysticetes from training activities using sonar and other active acoustic sources all occur during anti-submarine warfare activities as part of Major Training Exercises and tracking and torpedo exercises for surface ships. Predicted effects only include TTS level effects and behavioral responses. As discussed in Section 3.4.4.1 (Impacts from Sonar and Other Active Acoustic Sources), ranges to TTS for hull mounted sonar (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) can be on the order of several kilometers for up to 10 pings, whereas some behavioral effects could take place at distances up to 184 km, although meaningful behavioral effects are much more likely at higher received levels within a few kilometers of the sound source.

Regarding long-term impacts on blue whales, Goldbogen et al. (2013) reported on the results of an ongoing Navy-funded behavioral response study in the waters of Southern California (see Southall et al. 2012a for additional details on the behavioral response study). Goldbogen et al. (2013) suggested that "frequent exposure to mid-frequency anthropogenic sounds may pose significant risks to the recovery rates of endangered blue whale populations." While there are no data indicating any trend in the entire Eastern North Pacific population toward recovery since the end of whaling (e.g., Barlow and Forney 2007), research along the U.S. west coast and Baja California reported by Calambokidis et al. (2009b) and based on mark-recapture estimates "indicated a significant upward trend in abundance of blue whales" at a rate of increase just under 3 percent per year for the portion of the blue whale population in the Pacific that includes Southern California as part of its range. The Eastern North Pacific stock (population), which is occasionally present in Southern California, is known to migrate from the northern Gulf of Alaska to the eastern tropical Pacific at least as far south as the Costa Rica Dome (Carretta et al. 2013). Given this population's vast range and absent discussion of any other documented impacts, such as commercial ship strikes (Berman-Kowalewski et al. 2010), the suggestion by Goldbogen et al. (2013) that since the end of commercial whaling, sonar use (in the fraction of time and area represented by Navy's training and testing in the SOCAL Range Complex) may be of significant risk to the blue whale's recovery in the Pacific is speculative at this stage. Furthermore, the suggestion is contradicted by the upward trend in abundance and counts (Calambokidis et al. 2009b; Berman-Kowalewski et al. 2010) of blue whales in the area where sonar use has been occurring for decades.

Research and observations show that if mysticetes are exposed to sonar and other active acoustic sources such as sonar they may react in a number of ways depending on the characteristics of the sound source, their experience with the sound source, and whether they are migrating or on seasonal grounds (i.e., breeding or feeding). Reactions may include alerting, breaking off feeding dives and surfacing, diving or swimming away, or no response at all. Additionally, migrating mysticetes (such as humpback whales moving through the MITT Study Area) may divert around sound sources that are located within their path or may ignore a sound source depending on the context of the exposure.

Animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's ability to hear biologically relevant sounds. For exposures resulting in TTS, long-term consequences for individuals or populations would not be expected.

As shown in Table 3.4-17, there are no model-predicted PTS effects to mysticetes for training under the No Action Alternative.

Blue Whales (Endangered Species Act-Listed)

Blue whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that in the Study Area blue whales could be exposed to sound that may result in 18 TTS and 4 behavioral reactions per year. Long-term consequences for individuals or populations would not be expected.

Humpback Whales (Endangered Species Act-Listed)

Humpback whales may be exposed to sonar or other acoustic stressors associated with training activities throughout the year. In the Study Area, acoustic modeling predicts exposure to sound that may result in 501 TTS and 223 behavioral reactions per year. Long-term consequences for individuals or populations would not be expected.

Sei Whales (Endangered Species Act-Listed)

Sei whales may be exposed to sonar or other acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that sei whales in the Study Area could be exposed to sound that may result in 174 TTS and 73 behavioral reactions per year. Long-term consequences for individuals or populations would not be expected.

Fin Whales (Endangered Species Act-Listed)

Fin whales may be exposed to sonar or other acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that fin whales in the Study Area could be exposed to sound that may result in 17 TTS and 5 behavioral reactions per year. Long-term consequences for individuals or populations would not be expected.

Bryde's, Omura's, and Minke Whales (Not Endangered Species Act-Listed)

Bryde's, Omura's, and minke whales may be exposed to sonar or other active acoustic stressors associated with training activities. For Bryde's whales in the Study Area, acoustic modeling predicts exposure to sound that may result in 212 TTS and 100 behavioral reactions per year. For Omura's whales in the Study Area, acoustic modeling predicts exposure to sound that may result in 60 TTS and 24 behavioral reactions per year. For minke whales in the MITT Study Area, acoustic modeling predicts exposure to sound that may result in 67 TTS and 23 behavioral reactions per year. For all three species, long-term consequences would not be expected.

Odontocetes

Predicted impacts to odontocetes from training activities under the No Action Alterative from sonar and other active acoustic sources are all from anti-submarine warfare activities during Major Exercises and tracking and torpedo exercises for surface ships. As discussed in Section 3.4.4.1.1 (Range to Effects), ranges to TTS for hull mounted sonar (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) can be on the order of a few hundred meters for mid-frequency cetaceans. However, for high-frequency cetaceans (i.e., dwarf and pygmy sperm whales; genus *Kogia*) ranges to TTS for multiple pings can, under certain conditions, reach over (3 km) from a source. Some behavioral effects could take place at distances exceeding approximately 184 km for more sensitive species (high-frequency cetaceans and beaked whales), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Modeling predicts behavioral effects at long distance and low received levels but does not take into account background ambient noise levels or other competing biological sounds, which may mask sound from distant Navy sources. D'Spain and Batchelor (2006) conducted research on ambient sound levels off the coast of Southern California. The researchers measured a source spectral density of 105–120 dB re 1 μPa^2/Hz at 1 m (in the mid-frequency range) and calculated an estimated source level of 135–150 dB re 1 µPa at 1 m from various biologics (fish and marine mammals) contributing to underwater ambient sound levels recorded to the southeast of San Clemente Island, California.

Activities involving anti-submarine warfare training often involve multiple participants and activities associated with the event. More sensitive species of odontocetes such as beaked whales and dwarf and pygmy sperm whales may avoid the area for the duration of the event (see Section 3.4.3.1.2.6, Behavioral Responses, for a discussion of these species observed reactions sonar and other active acoustic sources). After the event ends, displaced animals would likely return to the area within a few days as seen in the Bahamas study with Blainville's beaked whales (Tyack et al. 2011). This would allow the animal to recover from any energy expenditure or missed resources, reducing the likelihood of long-term consequences for the individual or population.

Animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal’s ability to hear biologically relevant sounds. For exposures resulting in TTS, long-term consequences for individuals or populations would not be expected.

An annual total of 24 PTS exposures is predicted by the modeling, but because these only involve species of pygmy and dwarf sperm whale; discussion of those exposures is presented in detail below (see Pygmy and Dwarf Sperm Whales [*Kogia* spp.]).

Sperm Whales (Endangered Species Act-Listed)

Sperm whales (classified as mid-frequency cetaceans (see Section 3.4.2.3.2, Mid-Frequency Cetaceans) may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. For sperm whale in the Study Area, acoustic modeling predicts exposure to sound that may result in 4 TTS and 503 behavioral reactions per year.

Research and observations (see Section 3.4.3.1.2.6, Behavioral Responses) show that if sperm whales are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Sperm whales have shown resilience to acoustic and human disturbance, although they may react to sound sources and activities within a few kilometers. Sperm whales that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, avoid the area by swimming away or diving, or display aggressive behavior. As presented above for odontocetes in general, long-term consequences for sperm whale individuals or populations would not be expected.

False Killer Whale

False killer whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year in the Study Area.

Acoustic modeling for the false killer whale, predicts exposure to sound that may result in 29 TTS and 538 behavioral reactions per year. As presented above for odontocetes in general, long-term consequences for false killer whale individuals or populations would not be expected.

Beaked Whales

Beaked whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that the several species of beaked whales (i.e., Cuvier’s, Blainville’s, Longman’s, and ginkgo-toothed beaked whales) could be exposed to sound that may result in 79 TTS and 31,901 behavioral reactions. As discussed below, it is important to consider that there are behavioral responses that cannot be accounted for by the model, and as a result, the number of predicted behavioral reactions for beaked whales is considered a conservative estimate. For a more detailed description of the model and the assumptions made in predicting effects, see U.S. Department of the Navy (2013d; Marine Species Modeling Team 2013).

Research and observations (see 3.4.3.1.2.6, Behavioral Responses) show that if beaked whales are exposed to sonar or other active acoustic sources they may startle, break off feeding dives, and avoid the area of the sound source to levels of 157 dB re 1 µPa, or below (McCarthy et al. 2011). In research done at the Navy's instrumented tracking range in the Bahamas, animals leave the immediate area of the anti-submarine warfare training exercise, but return within a few days after the event ends (Claridge and Durban 2009, McCarthy et al. 2011, Moretti et al. 2009, Tyack et al. 2011). Passive acoustic monitoring of a training event at the Navy's instrumented range in Hawaii was undertaken during a Submarine Commander Course involving three surface ships and a submarine using mid-frequency sonar over the span of the multiple-day event. Manzano-Roth et al. (2013) determined that beaked whales (tentatively identified as Blainville's beaked whales) continued to make foraging dives at estimated distances of 13 to 52 km from active mid-frequency sonar, but that the animals shifted to the southern edge of the range with differences in the dive vocal period duration, and dive rate. De Ruiter et al. (2013a) presented results from two Cuvier's beaked whales that were tagged and exposed to simulated MFA sonar during the 2010 and 2011 field seasons of the Southern California behavioral response study (note that preliminary results from a similar behavioral response study in Southern California waters have been presented for the 2010–2011 field season [Southall 2011]). The 2011 tagged whales were also incidentally exposed to MFA sonar from a distant naval exercise. Received levels from the MFA sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa root mean square, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure from distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Cuvier's beaked whale responses suggested particular sensitivity to sound exposure as consistent with results for Blainville's beaked whale.

Based on these findings, significant behavioral reactions seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of kilometers (see Section 3.4.4.1, Impacts from Sonar and Other Active Acoustic Sources), especially for prolonged periods (a few hours or more) since research indicates beaked whales will leave an area where anthropogenic sound is present (Tyack et al. 2011; De Ruiter et al. 2013; Manzano-Roth et al. 2013).

The concern with beaked whales and an avoidance response is whether that displacement is likely to have long-term consequences for an animal or populations. Research involving tagged Cuvier's beaked whales in the SOCAL Range Complex reported on by Falcone and Schorr (2012, 2014) has documented movements in excess of hundreds of kilometers by some those animals. Schorr et al. (2014) reported the results for eight tagged Cuvier's beaked whales from the same area. Four of these eight whales made journeys of approximately 250 km from their tag deployment location, and one of the four made an extra-regional excursion over 450 km south to Mexico and back again. Given that some beaked whales may routinely move hundreds of kilometers as part of their normal pattern, temporarily leaving an area to avoid sonar or other anthropogenic activity may have little if any cost to such an animal. Photo identification studies in the SOCAL Range Complex have identified approximately 100 individual Cuvier's beaked whales with 40 percent having been seen in more than 1 year and with time spans between sightings of up to 7 years (Falcone and Schorr 2014). These results indicate long-term residency by beaked whales in an intensively used Navy training and testing area where sonar use is common and has been occurring for decades. These results suggest inconsequential effects or a lack of long-term consequences resulting from exposure to Navy training activities.

Moore and Barlow (2013) noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico, which is extremely more area than the Navy uses during training and testing. Interestingly, however, in the small portion of that area overlapping the Navy's Southern California Range Complex, long-term residency by individual Cuvier's beaked whales and higher densities suggest that the proposed decline noted elsewhere is not apparent where the Navy has been intensively training and testing with sonar and other systems for decades. Navy sonar training and testing is not conducted along a large part of the U.S. west coast from which Moore and Barlow (2013) drew their survey data. In Southern California, based on a series of surveys from 2006 to 2008 and a high number encounter rate, Falcone et al. (2009) suggested the ocean basin west of San Clemente Island may be an important region for Cuvier's beaked whales given the number of animals encountered there. Follow-up research (Falcone and Schorr 2012, 2014) in this same location suggests that Cuvier's beaked whales may have population sub units with higher than expected residency, particularly in Navy's instrumented Southern California Anti Submarine Warfare Range. Encounters with multiple groups of Cuvier's and Baird's beaked whales indicated not only that they were prevalent on the range where Navy routinely trains and tests, but also that they were potentially present in much higher densities than had been reported for anywhere along the U.S. west coast (Falcone et al. 2009, Falcone and Schorr 2012). This finding is also consistent with concurrent results from passive acoustic monitoring that estimated regional Cuvier's beaked whale densities were higher than indicated by NMFS's broad scale visual surveys for the U.S. west coast (Hildebrand and McDonald 2009).

Moore and Barlow (2013) suggest that one reason for the decline in beaked whales from Canada to Mexico may be as a result of anthropogenic sound, including the use of sonar by the U.S. Navy in the fraction of the U.S. Pacific coast overlapped by the Southern California Range Complex. Moore and Barlow (2013) recognized the inconsistencies between hypothesis and the abundance trends in the region of SOCAL Range Complex, stating: "High densities are not obviously consistent with a hypothesis that declines are due to military sonar, but they do not refute the possibility that declines have occurred in these areas (i.e., that densities were previously even higher)." While it is possible that the high densities of beaked whale currently inhabiting the Navy's range were even higher before the Navy began training with sonar, there are no data available to test that hypothesis. Furthermore, the decline of beaked whales Moore and Barlow (2013) assert for other areas of the U.S. west coast where the Navy does not conduct sonar training or testing limits the validity of their speculation about the effects of sonar on beaked whale populations.

Claridge (2013) used photo-recapture methods to estimate population abundance and demographics of Blainville's beaked whale (*Mesoplodon densirostris*) at two study sites in the Bahamas, one of which is regularly used for MFA sonar exercises. Claridge hypothesized that the reason a lower abundance was found at the site located within the bounds of the Navy's AUTEC range than at the site off Abaco Island is due either to reduced prey availability at AUTEC or to population-level effects from the exposure to MFA sonar at AUTEC. However, Claridge sampled half as frequently at AUTEC as at Abaco over the 5-year study period (102 versus 235 surveys), with only 20 encounter days at AUTEC from March to October versus 34 at Abaco. The estimated annual abundances at each location (31 [22–42] at AUTEC, 49 [38–62] at Abaco) was almost identical to the number of distinct (and therefore identifiable by photographic identification) individuals observed annually at each site (30 including 1 calf at AUTEC, 48 including 4 calves at Abaco). In fact, in the full 15-year study at Abaco (1997–2011), the estimated annual density was 42, and this population was considered to be part of a larger "parent" population in the area of approximately 135 whales.

All of the resighted whales at both sites were female. This leads to heterogeneity in the capture probability due to an age/sex bias, which can compromise the model fit and lead to negative bias in the estimation of abundances (Claridge 2013). The two study sites were each 300 km^2, an area that is small for known Blainville's beaked whale home ranges, based on tag data (e.g., Schorr et al. 2009). In addition, the population models for both sites were best described as an open population with re-immigration. At Abaco, over the 15-year study, many of the resighted females had sighting gaps of 5–10 years, but most of the animals were only observed in one year. This gap in resights is equal to or longer than the duration of the study at AUTEC.

These results indicate that there is both temporary and permanent emigration from the population at both sites, and that even over 15 years of research, the entire population (either the "parent" population or the smaller one at Abaco) was not entirely sampled (as indicated by the lack of an asymptote in the discovery curve of individuals from Abaco). In addition, beaked whales at AUTEC are known to leave the area for a few days following sonar activity (McCarthy et al. 2011, Tyack et al. 2011) so, depending on the timing of the photo-identification surveys, many animals may not have even been present to be sampled. Therefore, while Claridge did find a lower abundance at AUTEC than at Abaco, the results are biased by reduced effort and a study period that was not long enough to capture some of the emigration/immigration trends discovered at Abaco. In addition, while Claridge makes no mention of the "parent" population in comparing the study sites, she easily attributes the low site fidelity and small population size at Abaco to the larger movement patterns of these whales throughout the area, which could just as easily be done for the population at AUTEC.

Finally, when comparing only the 5-year study period between AUTEC and Abaco, the estimated abundance at Abaco appears to be almost double that of the AUTEC population; however, when the full 15-year dataset at Abaco is presented, the estimated annual abundance is approximately seven animals fewer (42 compared to 49), which is then only about 11 animals greater than the estimated annual abundance at AUTEC (31). Therefore the presentation of these population abundances as markedly different is questionable, and to attribute the difference largely to the presence of Navy sonar without considering ecological factors is poorly supported.

In an effort to understand beaked whale responses to stressors, New et al. (2013) developed a mathematical model simulating a functional link between foraging energetics and requirements for survival and reproduction for 21 species of beaked whale. New et al. (2013) report "reasonable confidence" in their model although approximately 29 percent (6 of 21 beaked whale species modeled) failed to survive or reproduce, which the authors attribute to possible inaccuracies in the underlying parameter values. Based on the model simulation, New et al. (2013) determined that if habitat quality and "accessible energy" (derived from the availability of either plentiful prey or prey with high energy content) are both high, then survival rates are high as well. If these variables are low, then adults may survive, but calves will not. The simulations suggested that adults will survive but not reproduce if anthropogenic disturbances resulted in them being displaced to areas of "impaired foraging."

Ecological modeling provides an important tool for exploring the properties of an animal's use of the environment and the factors that drive or contribute to survivorship and reproduction. The ability of any model to accurately predict real ecological processes is partly dictated by the ability of the modeler to correctly parameterize the model and incorporate assumptions that do not violate real-world conditions. Assumptions and parameters identified by New et al. (2013) that likely have a large effect on the model output include the period of reproduction (i.e., inter-calf interval) and prey selection (i.e., energy acquisition). Although New et al. (2013) concluded that anthropogenic disturbances might impair foraging through animal displacement and ultimately impact reproduction, the parameter values need to be revisited, as do assumptions that habitat capable of sustaining a beaked whale is limited in proximity to where any disturbance has occurred (i.e. beaked whales are likely not always in the most optimal foraging location).

While the New et al. (2013) model provides a test case for future research, the model has little of the critical data necessary to form conclusions applicable to current management decisions. There remains significant scientific uncertainty from which to infer modeled impacts to any marine species, especially reclusive beaked whales. For each population and sub-population, critical demographic data gaps still exist (adult survival, calf survival, juvenile survival, annual probability of calving, age at first calving, longevity, and an indication of likely levels of variation between years).The authors note the need for more data on prey species and reproductive parameters, including gestation and lactation duration, as the model results are particularly affected by these assumptions. Therefore, any suggestion of biological sensitivity to the simulation's input parameters is uncertain. Given this level of uncertainty, the Navy will continue to follow developments in the mathematical modeling of energetics to estimate specific sensitivity to disturbance. The Navy continues to fund the research and monitoring (such as the Behavioral Response Studies in the Bahamas and Southern California) specifically to better understand, via direct field observations, the potential for anthropogenic activities to disturb marine mammals. In cooperation with NMFS, the Navy will continue to develop the most effective management and conservation actions needed to protect marine mammals while accomplishing the Navy's mission to train and test safely and effectively.

The Navy has continued to review emerging science and fund research to better assess the potential impacts that may result from the continuation of ongoing training and testing in the historically used range complexes worldwide, as summarized in Section 3.4.5.2 (Summary of Observations During Previous Navy Activities). The Navy's assessment based on that compendium of data is that it is unlikely there would be impacts to populations of marine mammals having any long-term consequences as a result of the proposed continuation of training and testing in the ocean areas historically used by the Navy. This assessment of likelihood is based on four indicators from areas where Navy training and testing has been ongoing for decades: (1) evidence suggesting or documenting increases in the numbers of marine mammals present, (2) examples of documented presence and site fidelity of species and long-term residence by individual animals of some species, (3) use of training and testing areas for breeding and nursing activities, and (4) 6 years of comprehensive monitoring data indicating a lack of any observable effects to marine mammal populations as a result of Navy training and testing activities.

At the Bahamas range and at Navy instrumented ranges that have been operating for decades (in Hawaii north of Kauai and in Southern California west of San Clemente Island), populations of beaked whales appear to be stable (see Section 3.4.3.4, Marine Mammal Monitoring During Navy Training). Photographic evidence indicating re-sightings of individual beaked whales (from two species, Cuvier's and Blainville's beaked whales), suggesting long-term site fidelity to the area west of the Island of Hawaii (McSweeney et al. 2007), which is a channel used for years to conduct anti-submarine warfare training during Rim of the Pacific and Undersea Warfare Exercise (Major Exercises involving multiple vessels and aircraft). In Southern California to the west of San Clemente Island, surveys encountered a high number of Cuvier's beaked whales, leading Falcone et al. (2009) to suggest the area may be an important region for this species. For over three decades, this ocean area has been the location of the Navy's instrumented training range and is one of the most intensively used training and testing areas in the Pacific, given the proximity to the naval installations in San Diego.

Based on the best available science (McCarthy et al. 2011; Tyack et al. 2011; Southall et al. 2012b), the Navy believes that beaked whales that exhibit a significant behavioral reaction due to sonar and other active acoustic training activities would generally not have long-term consequences for individuals or populations. However, because of a lack of scientific consensus regarding the causal link between sonar and stranding events, NMFS has stated in a letter to the Navy dated October 2006 that it "cannot conclude with certainty the degree to which mitigation measures would eliminate or reduce the potential for serious injury or mortality." For over three decades, the ocean west of San Clemente Island has been the location of the Navy's instrumented training range and is one of the most intensively used training and testing areas in the Pacific. Research has documented the presence and long-term residence of Cuvier's beaked whales for the ocean basin west of San Clemente Island (Falcone et al. 2009, Falcone and Schorr 2012, 2014), and results from passive acoustic monitoring estimated regional Cuvier's beaked whale densities were higher than indicated by the NMFS's broad scale visual surveys for the U.S. west coast (Hildebrand and McDonald 2009).

Therefore, the Navy is requesting two serious injury or mortality takes for beaked whale species per year. This approach overestimates the potential effects to marine mammals associated with sonar training in the Study Area, as no mortality or serious injury of any species is anticipated. This request will be made even though Navy has conducted similar exercises in the Study Area without observed incident, which indicates that injury, strandings, and mortality are not expected to occur as a result of military activities. Neither NMFS nor the Navy anticipates that marine mammal strandings or mortality will result from the operation of sonar or other acoustic sources during military exercises within the Study Area. Additionally, through the MMPA process (which allows for adaptive management), NMFS and the Navy will determine the appropriate way to proceed in the event that a causal relationship were to be found between military activities and a future stranding involving beaked whale or other marine mammal species.

Costs and long-term consequences to the individual and population as a result of a beaked whale receiving a TTS is the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Pygmy and Dwarf Sperm Whales (Kogia spp.)

Pygmy and dwarf sperm whales (genus: *Kogia*) (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that dwarf sperm whale in the Study Area could be exposed to sound that may result in 18 PTS; 10,167 TTS; and 298 behavioral reactions. Acoustic modeling predicts that pygmy sperm whale in the Study Area could be exposed to sound that may result in 6 PTS; 3,825 TTS; and 111 behavioral reactions.

Research and observations (see Section 3.4.3.1.2.5, Behavioral Responses) on *Kogia* species are limited. However, these species tend to avoid human activity and presumably anthropogenic sounds. Pygmy and dwarf sperm whales may startle and leave the immediate area of the anti-submarine warfare training exercise. Significant behavioral reactions seem more likely than with most other odontocetes, however it is unlikely that animals would receive multiple exposures over a short time period allowing animals time to recover lost resources (e.g., food) or opportunities (e.g., mating). Therefore, long-term consequences for individual *Kogia* or their respective populations are not expected.

Costs and long-term consequences to the individual and population as a result of a *Kogia* receiving a PTS or TTS exposure is the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

For PTS, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Kloepper et al. 2010; Ketten 2012). Furthermore, likely avoidance of intense activity and sound coupled with mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the potential for PTS exposures to occur. Considering these factors, long-term consequences for individuals or populations would not be expected.

Dolphins, Porpoise, and Small Toothed Whales (Delphinids)

Delphinids (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Species included as delphinids for purposes of this discussion include the following: common bottlenose dolphin, Fraser's dolphin, killer whale, melon-headed whale, pantropical spotted dolphin, pygmy killer whale, Risso's dolphin, rough toothed dolphin, short-finned pilot whale, spinner dolphin, and striped dolphin. Acoustic modeling predicts that delphinids could be exposed to sound that may result in 1,649 TTS and 25,610 behavioral reactions.

Research and observations (see Section 3.4.3.1.2.5, Behavioral Responses) show that if delphinids are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Delphinids may not react at all until the sound source is approaching within a few hundred meters to within a few kilometers depending on the environmental conditions and species. Delphinids that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, change their behaviors or vocalizations, avoid the sound source by swimming away or diving, or be attracted to the sound source. Long-term consequences to individual delphinids or populations are not likely due to exposure to sonar or other active acoustic sources.

Costs and long-term consequences to the individual and population as a result of delphinids receiving an exposure resulting in TTS are the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Training activities under the No Action Alternative include the use of sonar and other active acoustic sources as described in Table 2.8-1 and Section 3.0.5.2.1 (Acoustic Stressors). Table 3.4-17 provides a summary of the annual estimated sound exposures resulting from the use of sonar and other active acoustic sources during military training under the No Action Alternative. Exposures at the behavioral (non-TTS), TTS, and PTS levels are presented. The acoustic modeling and post-modeling analyses indicate that 76,206 marine mammal exposures to sonar and other active acoustic sources may occur, resulting in Level B harassment as defined under the MMPA. Of these, 16,798 exposures would exceed the TTS threshold, and 59,408 behavioral exposures are predicted. Based on modeled estimates, 24 annual exposures would exceed the PTS threshold (Level A harassment).

Pursuant to the MMPA, sonar and other active acoustic sources used during training activities under the No Action Alternative:

- *May expose marine mammals up to 76,206 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 24 times annually to sound levels that would be considered Level A harassment*
- *May expose up to 2 beaked whales annually to sound levels that may elicit stranding and subsequent serious injury or mortality*

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities as described in the No Action Alternative:

- *May affect, and is likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing

As described in Chapter 2 (Description of Proposed Action and Alternatives, Tables 2.8-2, 2.8-3, 2.8-4), and Section 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources), no testing activities using sonar or other active acoustic sources are proposed under the No Action Alternative.

3.4.4.1.3.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1) and Section 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources), training activities under Alternative 1 that produce in-water sound from the use of sonar and other active acoustic sources would increase over those proposed under the No Action Alternative. Activities would occur in the same locations throughout the Study Area for all alternatives and would be concentrated within 200 nm of the Mariana Islands. New training activities proposed under Alternative 1 using sonar and other active acoustic sources that impact the modeling results include:

- Civilian Port Defense
- Mine Countermeasure – Towed Mine Detection
- Mine Countermeasure Exercise – Ship Sonar
- Mine Neutralization – Remotely Operated Vehicle
- Submarine Mine Exercise
- Submarine Navigation Exercise
- Submarine Sonar Maintenance
- Surface Ship Sonar Maintenance

Adjustments to the tempo of surface ship tracking exercises and torpedo exercises (TRACKEX/TORPEX Surface) under Alternative 1 result in a decrease of 317 sonar hours from sources in the MF1 bin, which includes a decrease in the number of annual sonar hours for the SQS-53 anti-submarine warfare hull-mounted sonar (see Section 3.0.5, Overall Approach to Analysis, Table 3.0-6). This adjustment to the tempo of training activities results in nearly a 15 percent decrease in the use of sources in the MF1 bin, which as discussed previously (see Section 3.4.4.1.1, Range to Effects), are the most powerful sonar sources and have the greatest probability of affecting marine mammals.

The inclusion of the new activities under Alternative 1 and adjustments to the location, type, and tempo of activities included under the No Action Alternative, result in a predicted increase in PTS and TTS exposures and a decrease in behavioral (non-TTS) exposures (Table 3.4-17). The acoustic modeling and post-modeling analyses indicate that 46 annual exposures to sonar and other active acoustic sources would exceed the PTS threshold (Level A harassment as defined under the MMPA) and 70,961 marine mammal exposures may result in Level B harassment. Of these, 22,630 exposures would exceed the TTS threshold, and 48,331 behavioral responses are predicted.

Under Alternative 1, TTS exposures to all marine mammals would increase by approximately 35 percent over the number of exposures predicted under the No Action Alternative. The number of PTS exposures would increase by 88 percent (from 24 to 45) under Alternative 1; however the number of non-TTS (behavioral) exposures would decrease by 23 percent compared to the number or behavioral exposures predicted under the No Action Alternative. Total predicted acoustic impacts (behavioral responses, TTS, and PTS) would decrease by approximately 7 percent under Alternative 1, because of the decrease in behavioral exposures.

Some training activities that use sonar and other active acoustic sources have the potential to occur, at least partially, in nearshore or littoral waters of the Study Area (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-1). It is possible, although unlikely, that these activities may occur in proximity to spinner dolphin resting areas identified in Section 3.4.2.23.2 (Spinner Dolphin, Geographic Range and Distribution). Several of these training activities occur infrequently (1–4 times per year). Other training activities would occur in nearshore areas where non-military activities also occur (e.g., Apra Harbor), which are unlikely to be spinner dolphin resting areas. To date, there have been no sightings of spinner dolphins in Apra Harbor.

The total number of exposures to spinner dolphins from all sonar and other active acoustic sources used in both the offshore and nearshore areas of the Study Area, not just from nearshore activities, is 84 TTS exposures and 419 behavioral responses. These predicted exposures are included in the estimated number of behavioral responses and TTS exposures presented in this section.

Mitigation, as described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), for activities occurring in offshore and nearshore areas of the Study Area would include surveying for marine mammals, including resting spinner dolphins, prior to conducting the activity. Given that nearshore activities occur infrequently, it would be unlikely that they would occur in the vicinity of spinner dolphin resting areas, and mitigation to avoid potential effects would be conducted. Therefore, no long-term consequences to spinner dolphins, such as habitat abandonment, are anticipated.

Notable results for Alternative 1 in comparison to results for the No Action Alternative are as follows:

- Predicted acoustic impacts (behavioral and TTS) on mysticetes overall would increase by less than 10 percent. TTS exposures for all mysticetes would increase between 0 percent (for minke whale) and 33 percent (for Bryde's whale). No PTS exposures on mysticetes are predicted under Alternative 1.
- Predicted TTS exposures on ESA-listed species would increase by about 27 percent for Alternative 1 as compared to the No Action Alternative. Predicted non-TTS (behavioral) exposures would decrease by about 27 percent.
- Combined TTS and PTS exposures predicted for dolphins and small-toothed whales would increase by about 34 percent. Predicted non-TTS (behavioral) exposures would decrease by about 23 percent.
- Predicted TTS exposures on beaked whales would increase from 81 under the No Action Alternative to 180 under Alternative 1. Approximately 60 percent of the TTS exposures predicted for beaked whales are on Cuvier's beaked whale and are associated with an increase in sonar use during the Joint Multi-Strike Group Exercise.

Increases in the number of predicted TTS and PTS exposures could mean an increase in the number of individual animals exposed per year or an increase in the number of times per year some individual animals are exposed, although the types and severity of individual responses to sonar and other active acoustic sources are not expected to change between Alternative 1 and the No Action Alternative.

Pursuant to the MMPA, sonar and other active acoustic sources used during training activities under Alternative 1:

- *May expose marine mammals up to 70,961 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 45 times annually to sound levels that would be considered Level A harassment*
- *May expose up to 2 beaked whales annually to sound levels that may elicit stranding and subsequent serious injury or mortality*

Pursuant to the ESA, the use of sonar and other acoustic sources during training activities as described in Alternative 1:

- *May affect, and is likely to adversely affect the humpback whale, sei whale, fin whale, blue whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As described in Chapter 2 (Description of Proposed Action and Alternatives, Tables 2.8-2, 2.8-3, 2.8-4) and Section 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources), testing activities under Alternative 1 that produce in-water sound from the use of sonar and other active acoustic sources would occur within the Study Area. Activities would be concentrated within 200 nm of the Mariana Islands. New testing activities proposed under Alternative 1 resulting in potential effects to marine mammals from sonar and other active acoustic sources include:

- Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft
- At-Sea Sonar Testing
- Countermeasure Testing
- Anti-Submarine Warfare Mission Package Testing
- Mine Countermeasures Mission Package Testing
- Pierside Integrated Swimmer Defense
- Ship Signature Testing
- Torpedo Testing

There are no testing activities using sonar and other active acoustic sources proposed under the No Action Alternative. The inclusion of new testing activities under Alternative 1 would increase predicted exposures to marine mammals (e.g., non-TTS behavioral responses, TTS, and PTS). As shown in Table 3.4-18, the acoustic modeling and post-modeling analyses indicate that 10 annual exposures to sonar and other active acoustic sources would exceed the PTS threshold (Level A harassment as defined under the MMPA), and 10,924 marine mammal exposures may result in Level B harassment. Of these, 4,066 exposures would exceed the TTS threshold, and the remaining 6,858 would be classified as behavioral responses.

Notable results for testing activities under Alternative 1 are as follows:

- The 10 predicted PTS exposures are to dwarf sperm whale (7) and pygmy sperm whale (3).
- Predicted acoustic impacts on ESA-listed species would total 135 TTS exposures and 64 non-TTS (behavioral) responses.
- Approximately 50 percent of all non-TTS (behavioral) responses are on Cuvier's beaked whales, and 64 percent of those responses are associated with Anti-Submarine Warfare Mission Package Testing.

No testing activities involving the use of sonar or other active acoustic sources are included as part of the No Action Alternative. Therefore, all predicted acoustic impacts (e.g., non-TTS, TTS, and PTS exposures) from testing activities would mean an increase in the number of animals exposed per year or an increase in the number of times per year some individual animals are exposed. The types and severity of individual responses to sonar and other active acoustic sources are not expected to be different than similar training activities described under Alternative 1 (Training) in this section.

Pursuant to the MMPA, sonar and other active acoustic sources used during testing activities under Alternative 1:

- *May expose marine mammals up to 10,924 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 10 times annually to sound levels that would be considered Level A harassment*

Pursuant to the ESA, the use of sonar and other acoustic sources during testing activities as described in Alternative 1:

- *May affect, and is likely to adversely affect the humpback whale, sei whale, fin whale, blue whale, sperm whale*

3.4.4.1.3.3 Alternative 2

Training

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1) and Section 3.0.5.2.1.1 (Sonar and Active Acoustic Sources), training activities under Alternative 2 that produce underwater sound from the use of sonar and other active acoustic sources would increase over those proposed under the No Action Alternative. Activities would occur in the same locations throughout the Study Area as presented for the No-Action Alternative and would be concentrated within 200 nm of the Mariana Islands. New training activities proposed under Alternative 2 using sonar and other active acoustic sources that impact the modeling results include:

- Fleet Strike Group Exercise
- Integrated Anti-Submarine Warfare Exercise
- Ship Squadron Anti-Submarine Warfare Exercise

The inclusion of these activities under Alternative 2 and adjustments to the location, type, and tempo of activities included under the No Action Alternative result in a predicted increase in PTS and TTS exposures and a decrease in behavioral (non-TTS) exposures. As is shown in Table 3.4-17, the acoustic modeling and post-modeling analyses indicate that 59 annual exposures to sound from sonar and other active acoustic sources would exceed the PTS threshold (Level A harassment as defined under the MMPA), and 102,616 marine mammal exposures may result in Level B harassment. Of these, 32,946 exposures would exceed the TTS threshold, and 69,670 behavioral responses are predicted.

Under Alternative 2, TTS exposures to all marine mammals would increase by approximately 145 percent over the number of exposures predicted under the No Action Alternative. The number of PTS exposures would increase by 96 percent (from 24 to 59) under Alternative 2, and the number of non-TTS (behavioral) exposures would increase by 17 percent compared to the number of behavioral exposures predicted under the No Action Alternative. Total predicted acoustic impacts (behavioral responses, TTS, and PTS) would increase by approximately 35 percent under Alternative 2.

Some training activities that use sonar or other active acoustic sources have the potential to occur, at least partially, in nearshore or littoral waters of the Study Area (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-1). It is possible, although unlikely, that these activities may occur in proximity to spinner dolphin resting areas identified in Section 3.4.2.23.2 (Spinner Dolphin, Geographic Range and Distribution). Several of these training activities occur infrequently (1–4 times per year). Other training activities would occur in nearshore areas where non-military activities also occur (e.g., Apra Harbor), which are unlikely to be spinner dolphin resting areas. To date, there have been no sightings of spinner dolphins in Apra Harbor.

The total number of exposures to spinner dolphins from all sonar and other active acoustic sources used in both the offshore and nearshore areas of the Study Area, not just from nearshore activities, is 103 TTS exposures and 579 behavioral responses. These predicted exposures are included in the estimated number of behavioral responses and TTS exposures presented in this section.

Mitigation, as described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), for activities occurring in offshore and nearshore areas of the Study Area would include surveying for marine mammals, including resting spinner dolphins, prior to conducting the activity. Given that nearshore activities occur infrequently, would be unlikely to occur in the vicinity of spinner dolphin resting areas, and mitigation to avoid potential effects would be conducted, no long-term consequences to spinner dolphins, such as habitat abandonment, are anticipated.

Notable results for Alternative 2 in comparison to results for the No Action Alternative and Alternative 1 are as follows:

- Predicted acoustic impacts (behavioral and TTS) on mysticetes overall would increase by about 60 percent over the No Action Alternative and 45 percent over Alternative 1. Predicted TTS exposures for all mysticetes would increase by 85 percent over the No Action Alternative and by about 50 percent over Alternative 1. No PTS exposures on mysticetes are predicted under Alternative 2.
- Predicted TTS exposures on ESA-listed species would increase by about 48 percent over the No Action Alternative and by about 46 percent over Alternative 1. No PTS exposures are predicted on ESA-listed species.
- Combined TTS and PTS exposures predicted for dolphins and small-toothed whales would increase by about 35 percent over the No Action Alternative and 23 percent over Alternative 1. Predicted non-TTS (behavioral) exposures would increase by about 17 percent over the No Action Alternative and 44 percent over Alternative 1.
- Predicted TTS exposures on beaked whales would increase from 79 under the No Action Alternative to 377 under Alternative 2. Predicted TTS exposures under Alternative 2 would increase by 30 percent over Alternative 1.
- Approximately 60 percent of the predicted TTS exposures on beaked whales under all three alternatives are on Cuvier's beaked whale, and 60–79 percent of TTS exposures on Cuvier's beaked whale are associated with sonar use during the Joint Multi-Strike Group Exercise.

Increases in the number of predicted acoustic impacts could mean an increase in the number of animals exposed per year or an increase in the number of times per year some individual animals are exposed, although the types and severity of individual responses to sonar and other active acoustic sources are not expected to change between Alternative 2 and the No Action Alternative.

Pursuant to the MMPA, sonar and other active acoustic sources used during training activities under Alternative 2:

- *May expose marine mammals up to 102,616 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 59 times annually to sound levels that would be considered Level A harassment*
- *May expose up to 2 beaked whales annually to sound levels that may elicit stranding and subsequent serious injury or mortality*

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities as described in Alternative 2:

- *May affect, and is likely to adversely affect the humpback whale, sei whale, fin whale, blue whale, and sperm whale*

Testing

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-2, 2.8-3, 2.8-4) and Section 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources), proposed testing activities involving sonar and other active acoustic sources under Alternative 2 would all be new, given none of these activities were proposed for the No Action Alternative. This section describes predicted impacts on marine mammals from testing activities under Alternative 2. These activities would occur throughout the Study Area and would be concentrated within 200 nm of the Mariana Islands.

Under Alternative 2, the number of annual testing activities would increase, including increases in the number of anti-submarine warfare events, mission package testing events, and at-sea sonar testing events (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-2, 2.8-3, 2.8-4). No new testing activities using sonar and other active acoustic sources are proposed under Alternative 2. The increase in proposed testing activities under Alternative 2 would result in an increase in predicted impacts to marine mammals (i.e., behavioral responses, TTS, and PTS) over the No Action Alternative (no sonar and other active acoustic activities; therefore no exposures) and Alternative 1.

As shown in Table 3.4-18, the acoustic modeling and post-modeling analyses indicate that 14 annual exposures to sound from sonar and other active acoustic sources would exceed the PTS threshold (Level A harassment as defined under the MMPA), and 13,065 marine mammal exposures may result in Level B harassment. Of these, 5,252 exposures would exceed the TTS threshold, and, the remaining 7,813 would be classified as behavioral responses.

Notable results for testing activities under Alternative 2 in comparison to Alternative 1 are as follows:

- The 14 predicted PTS exposures are on dwarf sperm whale (10) and pygmy sperm whale (4) and represent a 40 percent increase in total PTS exposures over Alternative 1.
- Predicted acoustic impacts on ESA-listed species total 76 non-TTS (behavioral) and 174 TTS exposures, an increase of about 20 percent and 10 percent over Alternative 1, respectively.

- Combined TTS and PTS exposures predicted for dolphins and small-toothed whales would increase by about 30 percent over Alternative 1. Predicted non-TTS (behavioral) exposures would increase by about 14 percent over Alternative 1.
- Approximately 50 percent of all non-TTS (behavioral) exposures on all marine mammals are on Cuvier's beaked whale, and 60 percent of all non-TTS (behavioral) exposures on Cuvier's beaked whale are associated with Anti-Submarine Warfare Mission Package Testing.

Increases in the number of acoustic impacts (non-TTS, TTS, and PTS) from testing activities would mean an increase in the number of animals exposed per year or an increase in the number of times per year some individual animals are exposed compared to predicted exposures under Alternative 1. The types and severity of individual responses to sonar and other active acoustic sources are not expected to change between Alternative 2 and Alternative 1.

Pursuant to the MMPA, sonar and other active acoustic sources used during testing activities under Alternative 2:

- *May expose marine mammals up to 13,065 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 14 times annually to sound levels that would be considered Level A harassment*

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities as described in Alternative 2:

- *May affect, and is likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2 Impacts from Explosives

Marine mammals could be exposed to energy and sound from underwater explosions associated with proposed activities as described in Chapter 2 (Description of Proposed Action and Alternatives). Explosives used during proposed military training and testing activities could occur throughout the Study Area. These activities include amphibious warfare, strike warfare, anti-surface warfare, anti-submarine warfare, and mine warfare. Activities that involve explosions are described in Chapter 2 (Description of Proposed Action and Alternatives).

The Navy Acoustic Effects Model (Marine Species Modeling Team 2013), in conjunction with the explosive thresholds and criteria are used to predict impacts on marine mammals from underwater explosions. Predicted impacts on marine mammals from at-sea explosions are based on a modeling approach that considers many factors. The equations for the models consider the net explosive weight (NEW), the properties of detonations underwater, and environmental factors such as depth of the explosion, overall water depth, water temperature, and bottom type. The NEW accounts for the mass and type of explosive material. Energy from explosions is capable of causing mortality, injury to the lungs or gastrointestinal tract, permanent or TTS, or a behavioral response depending on the level of exposure.

Section 3.4.3.1.2 (Analysis Background and Framework) presents the framework for the analysis of potential impacts. The death of an animal will, of course, eliminate future reproductive potential and cause a long-term consequence for the individual that must then be considered for potential long-term consequences for the population. Exposures that result in long-term injuries such as PTS may limit an animal's ability to find food, communicate with other animals, or interpret the environment around them. Impairment of these abilities can decrease an individual's chance of survival or impact its ability to successfully reproduce. TTS can also impair animal's abilities, but the TTS effect and the individual may recover quickly with little significant overall effect. Behavioral responses can include shorter surfacings, shorter dives, fewer blows (breaths) per surfacing, longer intervals between blows, ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (National Research Council 2005). However, it is not clear how these responses relate to long-term consequences for the individual or population (National Research Council 2005).

Explosions in the ocean or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. These sounds are likely within the audible range of most cetaceans, but the duration of individual sounds is very short. The direct sound from impulse sources such as explosions used during military training and testing activities last less than a second, and most events involve the use of only one or a few explosions. Furthermore, events are dispersed in time and throughout the Study Area. These factors reduce the likelihood of these sources causing substantial auditory masking in marine mammals.

Section 3.4.3.1.2.1 (Direct Injury) presents a review of observations and experiments involving marine mammals and reactions to impulse sounds and underwater explosions. Energy from explosions is capable of causing mortality, direct injury, hearing loss, or a behavioral response depending on the level of exposure. The death of an animal will, of course, eliminate future reproductive potential and must then be considered for potential long-term consequences for the population. Exposures that result in long-term injuries such as PTS may limit an animal's ability to find food, communicate with other animals, or interpret the surrounding environment. Impairment of these abilities can decrease an individual's chance of survival or impact its ability to successfully reproduce. TTS can also impair an animal's abilities, but the individual may recover quickly with little significant effect. Behavioral responses can include shorter surfacings, shorter dives, fewer blows (breaths) per surfacing, longer intervals between blows, ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (National Research Council 2005). However, it is not clear how these responses relate to long-term consequences for the individual or population (National Research Council 2005).

3.4.4.2.1 Range to Effects

This section describes the ranges (distances) to effects from an explosion as defined by specific criteria and explosive propagation calculations used in the Navy Acoustic Effects Model (Section 3.4.3.1.5.3). Marine mammals within these ranges are predicted to receive the associated effect. The range to effects is important information in estimating the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher-level effects, especially physiological effects such as injury and mortality. The ranges to effects are described below for explosive bins E2 (up to 0.5 lb. NEW)–E12 (up to 1,000 lb. NEW).

Figure 3.4-7 through Figure 3.4-10 show the range to slight lung injury and mortality for five representative animals of different masses for 0.5–1,000 lb. NEW detonations. Ranges for onset slight lung injury and onset mortality are based on the smallest calf weight in each category and therefore represents a conservative estimate (i.e., longer ranges) since populations contain many animals larger than calves and are therefore less susceptible to injurious effects. Animals within these water volumes would be expected to receive minor injuries at the outer ranges, increasing to more substantial injuries, and finally mortality as an animal approaches the detonation point.

Note that the modeling of proposed activities used species-specific masses and not the representative animal masses presented in Figure 3.4-7 through Figure 3.4-10.

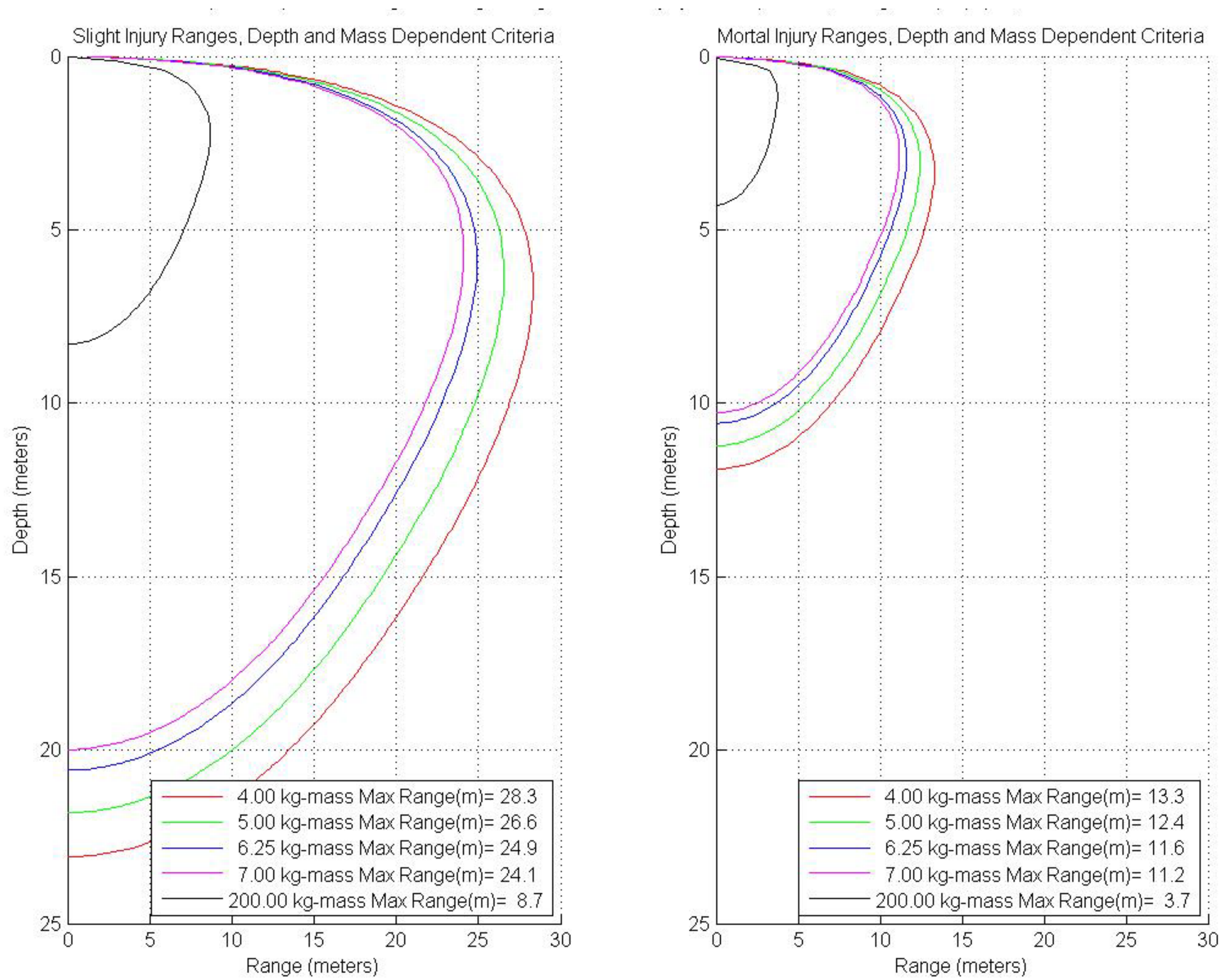

Figure 3.4-7: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 0.5-Pound Net Explosive Weight Charge (Bin E2) Detonated at 1-Meter Depth

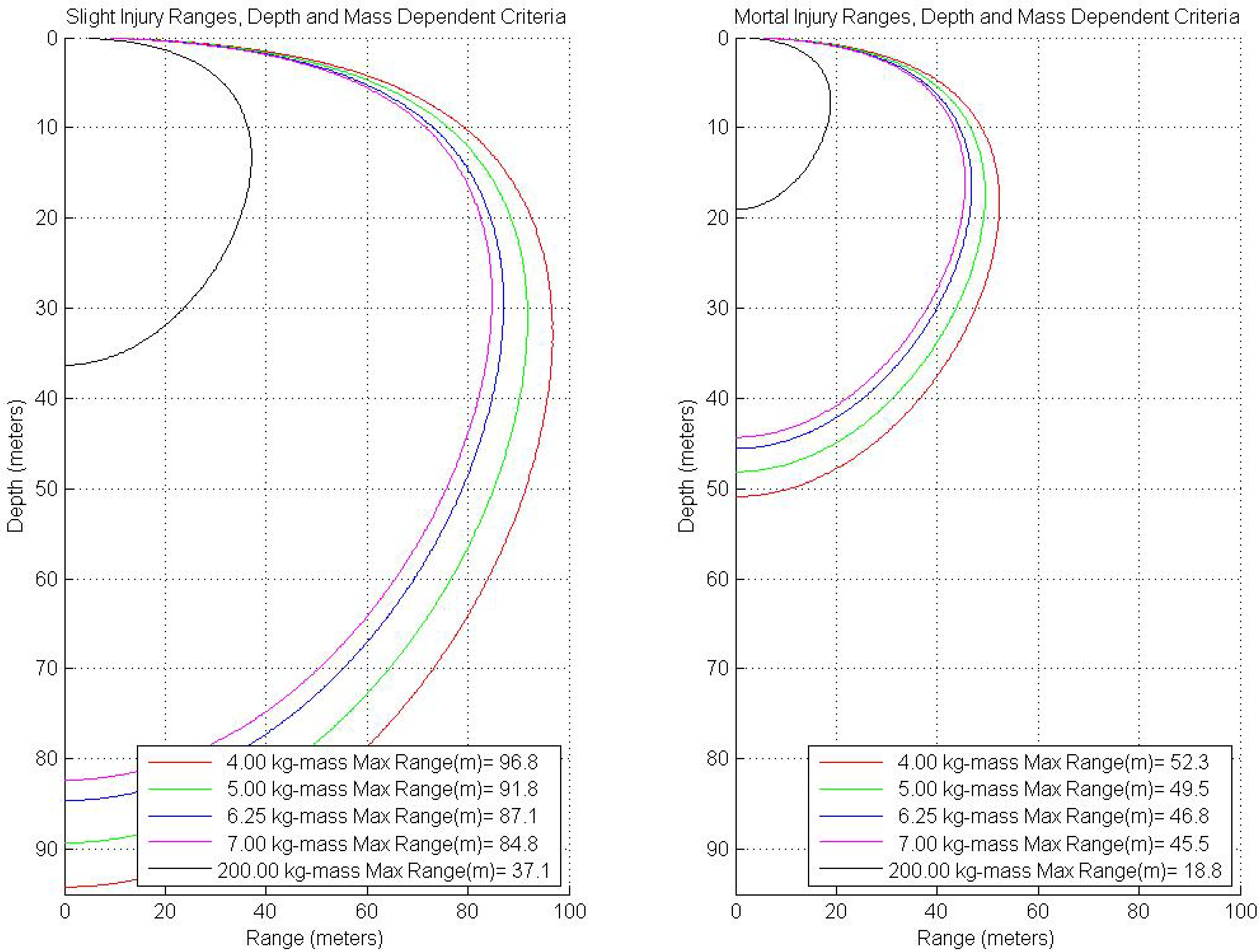

Figure 3.4-8: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 10-Pound Net Explosive Weight Charge (Bin E5) Detonated at 1-Meter Depth

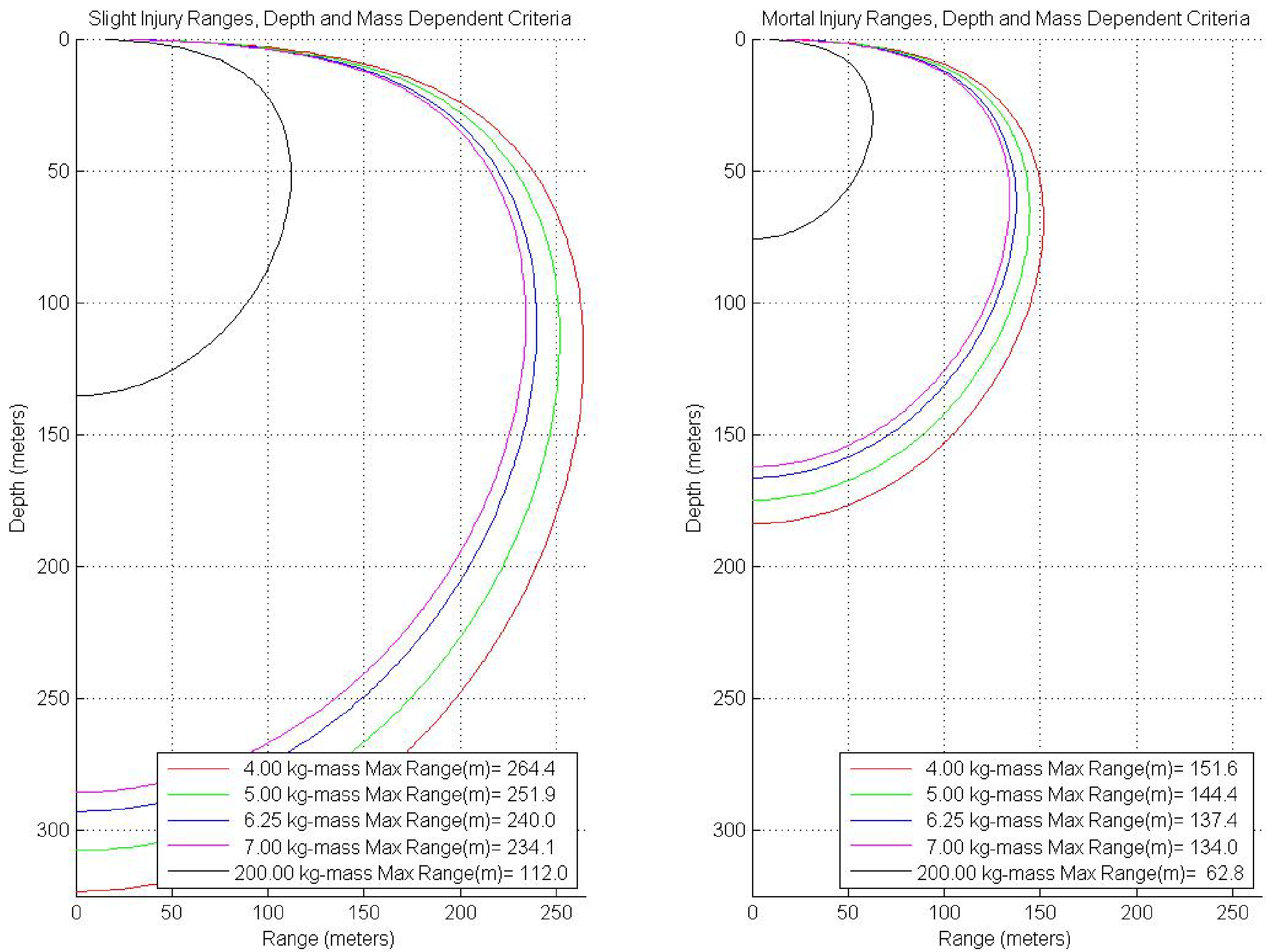

Figure 3.4-9: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 250-Pound Net Explosive Weight Charge (Bin E9) Detonated at 1-Meter Depth

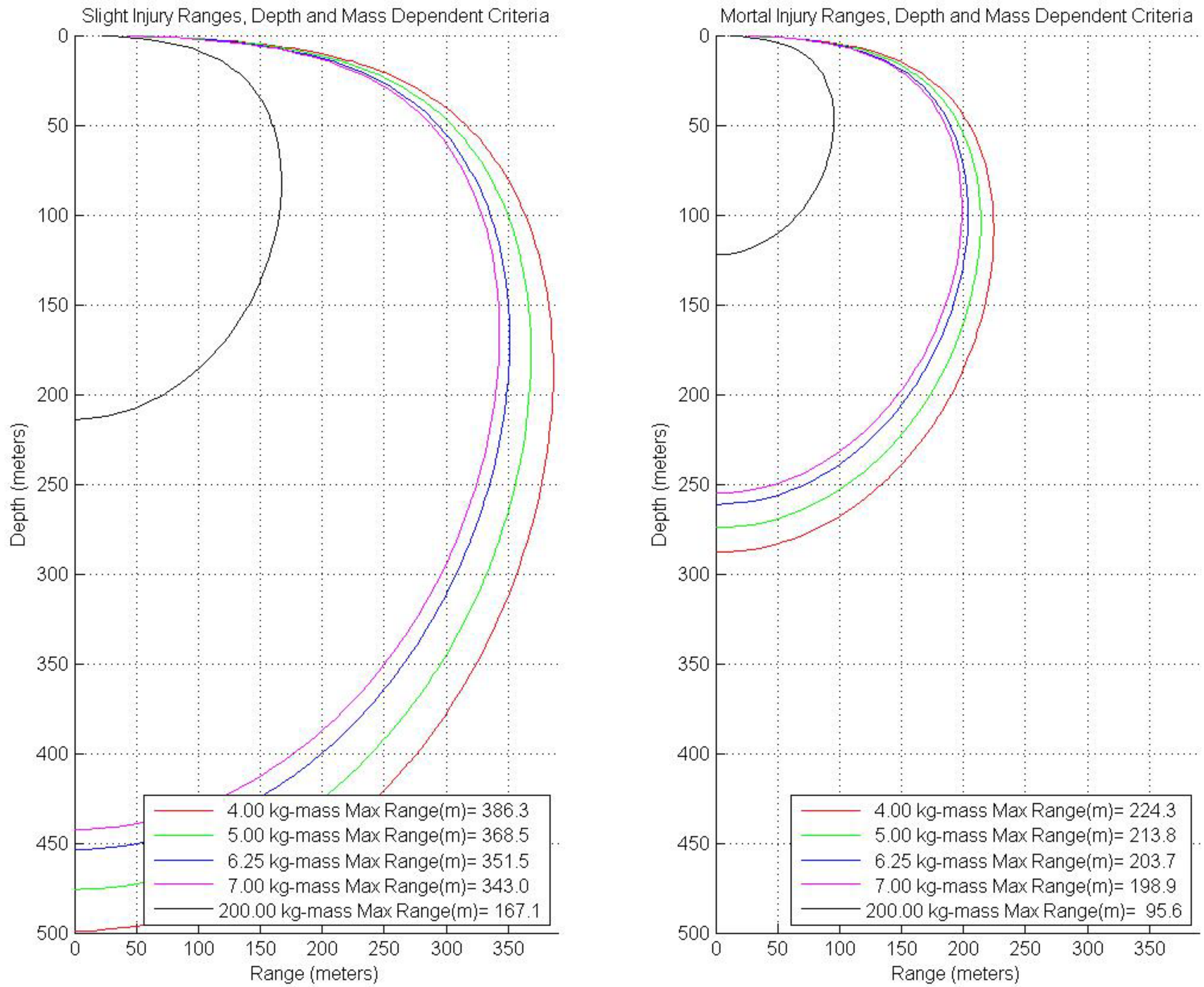

Figure 3.4-10: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 1,000-Pound Net Explosive Weight Charge (Bin E12) Detonated at 1-Meter Depth

Table 3.4-19 shows the average approximate ranges to the potential effect based on the thresholds described in Section 3.4.3.1.4 (Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). Similar to slight lung injury and mortality ranges discussed above, behavioral, TTS, and PTS ranges also represent conservative estimates (i.e., longer ranges) based on assuming all impulses are 1 second in duration. In fact, most impulses are much less than 1 second and therefore contain less energy than what is being used to produce the estimated ranges.

Explosions were modeled at the depths at which the explosive sources would typically be detonated during a training or testing activity. The depths at which explosives are detonated are not the same for all bins. The propagation of the energy generated by an explosion varies with depth and can lead to results that are contrary to the expected increase in distance with an increase in NEW (e.g., compare ranges for bin E7–bin E9).

Table 3.4-19: Average Approximate Range to Effects from a Single Explosion for Marine Mammals Across Representative Acoustic Environments (Nominal Values for Deep Water Offshore Areas; Not Specific to the Study Area)

Hearing Group Criteria/Predicted Impact	Average Approximate Range (meters) to Effects for Sample Explosive Bins					
	Bin E3 (>0.5–2.5 lb. NEW)	Bin E5 (>5–10 lb. NEW)	Bin E7 (>20–60 lb. NEW)	Bin E9 (>100–250 lb. NEW)	Bin E10 (>250–500 lb. NEW)	Bin E12 (>650–1,000 lb. NEW)
Low-frequency Cetaceans (calf weight 200 kg)						
Onset Mortality	10	20	80	65	80	95
Onset Slight Lung Injury	20	40	165	110	135	165
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	85	170	370	255	305	485
TTS	215	445	860	515	690	1,760
Behavioral Response	320	525	1,290	710	905	2,655
Mid-frequency Cetaceans (calf weight 5 kg)						
Onset Mortality	25	45	205	135	165	200
Onset Slight Lung Injury	50	85	390	235	285	345
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	35	70	160	170	205	265
TTS	100	215	480	355	435	720
Behavioral Response	135	285	640	455	555	970
High-frequency Cetaceans (calf weight 4 kg)						
Onset Mortality	30	50	225	145	175	215
Onset Slight Lung Injury	55	90	425	250	305	370
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	140	375	710	470	570	855
TTS	500	705	4,125	810	945	2,415
Behavioral Response	570	930	5,030	2,010	4,965	5,705

Notes: GI = gastrointestinal, kg = kilograms, lb. = pounds, NEW = net explosive weight, PTS = permanent threshold shift, TTS = temporary threshold shift

3.4.4.2.2 Avoidance Behavior and Mitigation Measures as Applied to Explosions

As previously discussed, within the Navy Acoustic Effects Model, animats do not move horizontally or react in any way to avoid sound at any level. In reality, researchers have demonstrated that cetaceans can perceive the location and movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Watkins 1986; Würsig et al. 1998; Richardson et al. 1995; Jansen et al. 2010; Tyack et al. 2011). Section 3.4.3.1.2 (Analysis Background and Framework) reviews research and observations of marine mammals' reactions to sound sources including seismic surveys and explosives. The Navy Acoustic Effects Model also does not account for the implementation of mitigation, which would prevent many of the model-predicted injurious and mortal exposures to explosives. Therefore, the model-estimated mortality and Level A effects are further analyzed and adjusted to account for animal movement (avoidance) and implementation of mitigation measures.

If explosive activities are preceded by multiple vessel traffic or hovering aircraft, beaked whales are assumed to move beyond the range to onset mortality before detonations occur. Table 3.4-19 shows the ranges to onset mortality for mid-frequency and high-frequency cetaceans for a representative range of charge sizes. The range to onset mortality for all NEWs is less than 280 yd. (260 m), which is conservatively based on range to onset mortality for a calf. Because the Navy Acoustic Effects Model does not include avoidance behavior, the model-estimated mortalities are based on unlikely behavior for these species—that they would tolerate staying in an area of high human activity. Therefore, beaked whales that were model-estimated to be within range of a mortality criterion exposure are assumed to avoid the activity and analyzed as being in the range of potential injury prior to the start of the explosive activity for the activities listed in Table 3.4-20.

Table 3.4-20: Activities Using Impulse Sources Preceded by Multiple Vessel Movements or Hovering Helicopters for the Mariana Islands Training and Testing Study Area

Training
Civilian Port Defense
Gunnery Exercise (Surface-to-Surface) Ship/Boat – Medium-caliber
Maritime Security Operations
Missile Exercise (Air-to-Surface)
Missile Exercise (Air-to-Surface)– Rocket
Mine Neutralization – Explosive Ordnance Disposal
Mine Neutralization – Remotely Operated Vehicle
Sinking Exercise
Underwater Demolition Qualification/Certification
Testing
Mine Countermeasure Mission Package Testing
Pierside Integrated Swimmer Defense
Torpedo Testing

The Navy Acoustic Effects Model does not consider mitigation, discussed in detail in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), Section 5.3 (Mitigation Assessment). As explained in Section 3.4.3.3 (Implementing Mitigation to Reduce Sound Exposures), to account for the implementation of mitigation measures, the acoustic analysis assumes a model-predicted mortality or injury would not occur if an animal at the water surface would likely be observed during those activities with dedicated Lookouts up to and during the use of explosives, considering the mitigation effectiveness (Table 3.4-21) and sightability of a species based on g(0) (see Table 3.4-8). The mitigation effectiveness is considered over two regions of an activity's mitigation zone: (1) the range to onset mortality closer to the explosion and (2) range to onset PTS. The model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen (Mitigation Effectiveness x Sightability, g(0)); these animals are instead assumed to be present within the range to injury and range to TTS, respectively.

Table 3.4-21: Adjustment Factors for Activities Using Explosives Integrating Implementation of Mitigation into Modeling Analyses for the Mariana Islands Training and Testing Study Area

Activity[1]	Factor for Adjustment of Preliminary Modeling Estimates[2]		Mitigation Platform Used for Assessment
	Injury Zone	Mortality Zone	
Training			
BOMBEX [A-S] (HF/LF)	0	1	Aircraft
BOMBEX [A-S] (MF)	0.5	1	Aircraft
Civilian Port Defense	1	1	Vessel
Maritime Security Operations	1	1	Both[3]
Mine Neutralization – EOD	0.5	1	Vessel
Mine Neutralization – ROV	1	1	Vessel
Fleet Strike Group Exercise	0.5	0.5	Both[3]
GUNEX [A-S] – Medium-Caliber (BW/HF)	0.5	0.5	Aircraft
GUNEX [A-S] – Medium-Caliber (LF/MF)	1	1	Aircraft
GUNEX [S-S] – Boat – Medium-Caliber (BW/HF)	0.5	0.5	Vessel
GUNEX [S-S] – Boat – Medium-Caliber (MF/LF)	1	1	Vessel
GUNEX [S-S] – Ship – Medium-Caliber (BW/HF)	0.5	0.5	Vessel
GUNEX [S-S] – Ship – Medium-Caliber (MF/LF)	1	1	Vessel
Joint Expeditionary Exercise	0.5	0.5	Both[3]
Joint Multi-CSG Exercise	0.5	0.5	Both[3]
SINKEX (HF/LF)	0.5	1	Aircraft
SINKEX (MF)	0.5	1	Aircraft
TRACKEX/TORPEX – MPA AEER/IEER	0.5	0.5	Aircraft
Underwater Demolition Qualification/Certification	1	1	Vessel
Testing			
MCM Mission Package Testing	1	1	Vessel
Torpedo Testing	0.5	1	Aircraft

[1] Ranges to effect differ for functional hearing groups based on weighted threshold values. HF: high-frequency cetaceans; MF: mid-frequency cetaceans; LF: low-frequency cetaceans. The adjustment factor for all other activities (not listed) is zero and there is no adjustment of the preliminary modeling estimates as a result of implemented mitigation for those activities.
[2] A zero value is provided if the predicted maximum zone for the criteria is large and exceeds what mitigation procedures are likely to affect; a zero value indicates mitigation did not adjust or reduce the predicted exposures under that criteria.
[3] Activity employs both vessel and aircraft based Lookouts. The larger g(0) value (aerial or vessel) is used to estimate sightability.
Notes: A-S = air-to-surface, AEER = Advanced Extended Echo Ranging, BOMBEX = Bombing Exercise, BW = beaked whale, CSG = Carrier Strike Group, EOD = Explosive Ordnance Disposal, GUNEX = Gun Exercise, HF = high-frequency, IEER = Improved Extended Echo Ranging, LF = low-frequency, MCM = mine countermeasure, MF = mid-frequency, MISSILEX = Missile Exercise, MPA = Maritime Patrol Aircraft, S-S = surface-to-surface, SINKEX = Sinking Exercise, TORPEX = Torpedo Exercise, TRACKEX = Tracking Exercise

During an activity with a series of explosions (not concurrent multiple explosions [Table 3.4-22]), an animal is expected to exhibit an initial startle reaction to the first detonation, followed by a behavioral response after multiple detonations. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area around the explosions is the assumed behavioral response for most cases. The ranges to PTS for each functional hearing group for a range of explosive sizes (single detonation) are shown in Table 3.4-19. Animals not observed by Lookouts within the ranges to PTS at the time of the initial couple of explosions are assumed to experience PTS; however, animals that exhibit avoidance reactions beyond the initial range to PTS are assumed to move away from the expanding range to PTS effects with each additional explosion.

Additionally, odontocetes have been demonstrated to have directional hearing, with best hearing sensitivity facing a sound source (Mooney et al. 2008; Popov and Supin 2009; Kastelein et al. 2005). An odontocete avoiding a source would receive sounds along a less sensitive hearing axis, potentially reducing impacts. Because the Navy Acoustic Effects Model does not account for avoidance behavior, the model-estimated effects are based on unlikely behavior that animals would remain in the vicinity of potentially injurious sound sources. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur. The remaining model-estimated PTS are considered to be TTS due to avoidance. The remaining model-estimated PTS exposures (resulting from accumulated energy) are considered to be TTS due to avoidance. Activities involving multiple non-concurrent explosive or other impulsive sources are listed in Table 3.4-22.

Table 3.4-22: Activities with Multiple Non-Concurrent Explosions

Training
BOMBEX (A-S)
Civilian Port Defense
GUNEX (A-S)
GUNEX (S-S) – Medium-caliber
GUNEX (S-S) – Large caliber
Mine Neutralization – EOD
Mine Neutralization – ROV
SINKEX
Testing
MCM Mission Package Testing
ASUW Mission Package Testing

Notes: A-S = air-to-surface, ASUW = Anti-Surface Warfare, BOMBEX = Bombing Exercise, EOD = Explosive Ordnance Disposal, GUNEX = Gunnery Exercise, MCM = mine countermeasure, ROV = remotely operated vehicle, S-S = surface-to-surface, SINKEX = Sinking Exercise

3.4.4.2.3 Predicted Impacts from Explosives

Predicted impacts to marine mammals from impulse sources for training activities (Table 3.4-23) and testing activities (Table 3.4-24) are presented for Alternative 1 and Alternative 2 (the predicted impacts for the two alternatives are the same). There are no modeling predicted effects to marine mammals as a result of the No Action Alternative for testing or training activities using impulse sources. The totals presented in these tables are the summation of all proposed events occurring annually.

It is also important to note that impacts from impulse sources presented in Table 3.4-23 and Table 3.4-24: are the total number of exposures and not necessarily the number of individuals exposed. As discussed in Section 3.4.3.1.4.3 (Behavioral Responses) an animal could be predicted to receive more than one acoustic impact over the course of a year. Species presented in the tables had species density values (i.e., theoretically present to some degree) within the areas modeled for the given alternative and activities, although modeling may still indicate no exposures after summing all annual impacts.

The analysis of acoustic effects from explosives uses the Navy Acoustic Effects Model followed by post-model consideration of avoidance and implementation of mitigation to predict effects using the explosive criteria and thresholds.

As presented previously, the Navy Acoustic Effects Model accounts for several limitations in the data needed for the model by making assumptions that are believed to overestimate the number of animal exposures to impulse and non-impulse sound sources (Section 3.4.3.1.5.4, Model Assumptions and Limitations). When there is uncertainty in model input values, a conservative approach has been adopted to assure that potential effects are not under predicted. As a result, the Navy Acoustic Effects Model provides predictions that are conservative (in that it over predicts the likely impacts). The following is a list of additional factors that cause the model to overestimate potential injury effects from impulse sound sources (e.g., explosions):

- The onset mortality criterion is based on the impulse at which 1 percent of the animals receiving an injury would not recover. Therefore, many predicted mortalities in this analysis may actually represent animals that recover from their injuries.
- Slight lung injury criteria are based on the impulse at which 1 percent of the animals exposed would incur a slight lung injury from which full recovery would be expected. Therefore, many predicted slight lung injury exposures in this analysis may not actually result in injuries to animals.
- The metrics used for the threshold for slight lung injury and mortality (i.e., acoustic impulse) are based on the animal's mass. The smaller an animal, the more susceptible that individual is to these effects. In this analysis, all individuals of a given species are assigned the weight of that species newborn. Since many individuals in a population are obviously larger than a newborn calf of that species, this assumption causes the acoustic model to overestimate the number of animals that may incur slight lung injury or mortality. As discussed in the explanation of onset mortality and onset slight lung injury criteria, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.
- Many explosions from munitions such as bombs and missiles will actually occur upon impact with above-water targets. However, for this analysis, sources such as these were modeled as exploding at 1 m depth. This overestimates the amount of explosive and acoustic energy entering the water and therefore overestimates effects on marine mammals.
- The Navy Acoustic Effects Model does not account for animal avoidance behavior that would most likely occur during activities that involve multiple explosives. Animal avoidance would decrease the effects predicted in this analysis.

Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) provide additional protections, many of which are not considered in the following exposure summary tables since reductions as a result of implemented mitigation were only applied to those events having a very high likelihood of detecting marine mammals.

3.4.4.2.3.1 No Action Alternative, Alternative 1, and Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1) and Section 3.0.5.2.1.2 (Explosives) training activities would use underwater detonations and explosive ordnance under all three alternatives. Training activities involving explosions could be conducted throughout the Study Area and typically occur more than 3 nm from shore. Exceptions to this are events that have historically occurred in Apra Harbor and other nearshore shallow water locations designated for military use.

Under the No Action Alternative, there are no model-predicted effects to marine mammals from training activities using impulse sources. New training activities proposed under Alternative 1 using sonar and other active acoustic sources that impact the modeling results include:

- Gunnery (Air-to-Surface) Medium-Caliber
- Gunnery (Surface-to-Surface) Boat – Medium-Caliber
- Gunnery (Surface-to-Surface) Ship – Medium-Caliber
- Joint Expeditionary Exercise
- Joint Multi-Carrier Strike Group Exercise
- Civilian Port Defense
- Maritime Security Operations
- Missile Exercise (Surface-to-Surface)

One new training activity that uses sonar and other active acoustic sources, the Fleet Strike Group Exercise, is proposed under Alternative 2. This activity occurs one time per year.

As presented in Table 3.4-23, modeling predicts the identical number of effects for Alternative 1 and Alternative 2. No exposures are predicted from impulse sound or underwater detonations during training events that would result in slight lung injury or mortality. One MMPA Level A exposure at the PTS level is predicted, and six exposures to marine mammals are predicted at the TTS level. The modeling results and a historical record of conducting the same or similar events for decades in the Pacific indicates Level A exposures are unlikely.

Mysticetes

There are no predicted impacts on mysticetes from impulse sources (explosions and detonations) associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Blue Whales (Endangered Species Act-Listed)

There are no predicted impacts on blue whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Fin Whales (Endangered Species Act-Listed)

There are no predicted impacts on fin whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Table 3.4-23: Alternative 1 and Alternative 2 Annual Training Exposure Summary for Impulse Sound Sources[1]

Species	Level B		Level A			
	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Blainville's Beaked Whale	0	0	0	0	0	0
Blue Whale	0	0	0	0	0	0
Bottlenose Dolphin	0	0	0	0	0	0
Bryde's Whale	0	0	0	0	0	0
Minke Whale	0	0	0	0	0	0
Cuvier's Beaked Whale	0	0	0	0	0	0
Dwarf Sperm Whale	0	3	1	0	0	0
False Killer Whale	0	0	0	0	0	0
Fin Whale	0	0	0	0	0	0
Fraser's Dolphin	0	1	0	0	0	0
Ginkgo-toothed Beaked Whale	0	0	0	0	0	0
Humpback Whale	0	0	0	0	0	0
Killer Whale	0	0	0	0	0	0
Longman's Beaked Whale	0	0	0	0	0	0
Melon-headed Whale	0	0	0	0	0	0
Omura's Whale	0	0	0	0	0	0
Pantropical Spotted Dolphin	0	1	0	0	0	0
Pygmy Killer Whale	0	0	0	0	0	0
Pygmy Sperm Whale	0	1	0	0	0	0
Risso's Dolphin	0	0	0	0	0	0
Rough Toothed Dolphin	0	0	0	0	0	0
Sei Whale	0	0	0	0	0	0
Short-finned Pilot Whale	0	0	0	0	0	0
Sperm Whale	0	0	0	0	0	0
Spinner Dolphin	0	0	0	0	0	0
Striped Dolphin	0	0	0	0	0	0
Total Predicted Exposures	**0**	**6**	**1**	**0**	**0**	**0**

[1] There are no predicted exposures from impulse sound sources under the No Action Alternative.
Notes: GI = gastrointestinal, PTS = permanent threshold shift, TTS = temporary threshold shift

Humpback Whales (Endangered Species Act-Listed)

There are no predicted impacts on humpback whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Sei Whales (Endangered Species Act-Listed)

There are no predicted impacts on sei whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Odontocetes

Predicted impacts to odontocetes under all three alternatives are from sound or energy caused by explosions, and all are associated with the Bombing Exercise (air-to-surface) training activity.

Sperm Whales (Endangered Species Act-Listed)

There are no predicted impacts on sperm whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Beaked Whales

There are no predicted impacts on beaked whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Pygmy and Dwarf Sperm Whales (Kogia spp.)

Pygmy and dwarf sperm whales (genus: *Kogia*) (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) may be exposed to sound or energy from explosions associated with training activities throughout the year. Acoustic modeling predicts that dwarf sperm whales could be exposed to sound or energy from explosions that may result in three TTS level exposures and one PTS level exposure per year. Pygmy sperm whales could be exposed to sound or energy from explosions that may result in one TTS level exposure per year. For reasons described in Section 3.4.4.2.3 (Predicted Impacts from Impulse Sources) no long-term consequences for individuals or populations of dwarf or pygmy sperm whales would be expected.

Recovery from a TTS effect (i.e., temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Animals would not fully recover from the PTS effect. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal’s ability to detect biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for an individual given that many mammals lose their hearing ability as they age. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts.

Dolphins and Small Toothed Whales (Delphinids)

Fraser's dolphin and pantropical spotted dolphin are the only two Delphinids (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) that modeling predicts may be affected by explosions. One TTS level exposure is predicted for Fraser’s dolphin, and one TTS level exposure is predicted for pantropical spotted dolphin per year. No MMPA Level A exposures are predicted for either species.

As with other marine mammal species, recovery from a TTS effect (i.e., temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal’s ability to detect biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for an individual given that many mammals lose their hearing ability as they age (Ridgway et al. 1997; Southall et al. 2007; Kloepper et al. 2010).

Research and observations (Section 3.4.3.1.2.6, Behavioral Responses) suggest that if delphinids are exposed to explosions, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Some behavioral impacts could take place at distances of approximately 970 m (0.6 mi.) for a Bombing Exercise (air-to-surface) event, although significant behavioral effects are much more likely at higher received levels closer to the sound and energy source. Resting sites for spinner dolphins have been identified in nearshore waters of the

Study Area (see Section 3.4.2.23.2). As shown in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1), three major training exercises and one mine warfare activity (the Limpet Mine Neutralization System/Shock Wave Generator activity) could involve some level of activity in nearshore or littoral waters. However, use of explosives would occur in offshore areas of the Study Area or in areas specifically designated for detonations and would be unlikely to affect resting spinner dolphins. Spinner dolphins have been cited in the vicinity of FDM, and although multiple training activities use explosives at FDM, all detonations would occur on land. No exposures of spinner dolphins to explosives effects are predicted by the Navy's Acoustics Effects Model.

Overall, the number of predicted behavioral reactions is low, and occasional behavioral responses are unlikely to cause long-term consequences for individual animals or marine mammal populations. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce potential impacts.

Conclusion

Training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2) include sound or energy from underwater explosions resulting from activities as described in Table 2.8-1 of Chapter 2 (Description of Proposed Action and Alternatives) and in Section 3.0.5.2.1.2 (Explosives). There are no modeled effects to marine mammals as a result of the No Action Alternative. Under Alternative 1 and Alternative 2 the proposed actions resulting in exposures are identical, and these activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of explosives during training activities under Alternative 1 and Alternative 2:

- *May expose marine mammals up to 6 times annually to sound or pressure levels that would be considered Level B harassment*
- *May expose marine mammals up to 1 time annually to sound or pressure levels that would be considered Level A harassment*

(There are no model-predicted effects to marine mammals as a result of the No Action Alternative for training activities using explosive sources)

Pursuant to the ESA, the use of explosives during training activities as described for all alternatives (No Action Alternative, Alternative 1, and Alternative 2):

- *May affect, but is not likely to adversely affect blue whale, humpback whale, sei whale, fin whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-2–Table 2.8-4) and Section 3.0.5.2.1.2 (Explosives), testing activities under Alternative 1 and Alternative 2 would use underwater detonations and explosive ordnance. There are no testing activities using explosives or other impulse sound sources under the No Action Alternative.

Testing activities involving explosives could be conducted throughout the Study Area and would typically occur more than 3 nm from shore. Exceptions to this are testing activities that occur in Apra Harbor and other nearshore shallow water locations designated for military use and where similar activities have historically occurred.

As presented in Table 3.4-24, only non-TTS (behavioral) exposures for testing activities are predicted by the Navy's Acoustics Effects Model. No TTS level, MMPA Level A, injury, or mortality exposures are predicted from testing activities using explosive sound sources. Under Alternative 1, 15 behavioral exposures per year to marine mammals are predicted from impulse sound sources used during the proposed testing activities. Under Alternative 2, 18 behavioral exposures per year are predicted.

Mysticetes

There are no MMPA Level A or Level B exposures on mysticetes from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Blue Whales (Endangered Species Act-Listed)

There are no predicted impacts on blue whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Fin Whales (Endangered Species Act-Listed)

There are no predicted impacts on fin whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Humpback Whales (Endangered Species Act-Listed)

There are no predicted impacts on humpback whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Sei Whales (Endangered Species Act-Listed)

There are no predicted impacts on sei whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Odontocetes

Predicted effects to odontocetes from testing activities using explosive sources under Alternative 1 and Alternative 2 are on *Kogia* species.

Sperm Whales (Endangered Species Act-Listed)

There are no predicted impacts on sperm whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Beaked Whales

There are no predicted impacts on beaked whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Pygmy and Dwarf Sperm Whales (Kogia spp.)

Pygmy and dwarf sperm whales (genus: *Kogia*) (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) may be exposed to impulse sound or energy from explosions and detonations associated with testing activities throughout the year. Acoustic modeling predicts that dwarf sperm whales could be exposed to impulse sounds resulting in 12 non-TTS behavioral responses per year under Alternative 1 and 14 non-TTS behavioral responses per year under Alternative 2. Acoustic modeling predicts that pygmy sperm whales could be exposed to impulse sounds resulting in 3 non-TTS behavioral exposures per year under Alternative 1 and 4 non-TTS behavioral exposures per year under Alternative 2. No TTS level exposures or MMPA Level A exposures for any species are predicted. No long-term consequences for individuals or populations of *Kogia* species would be expected.

Table 3.4-24: Alternative 1 and Alternative 2 Annual Testing Exposure Summary for Explosive Sources[1]

Species	Level B			Level A			
	Behavioral		TTS	PTS	GI Injury	Lung Injury	Mortality
	Alternative 1	Alternative 2					
Blainville's Beaked Whale	0	0	0	0	0	0	0
Blue Whale	0	0	0	0	0	0	0
Bottlenose Dolphin	0	0	0	0	0	0	0
Bryde's Whale	0	0	0	0	0	0	0
Minke Whale	0	0	0	0	0	0	0
Cuvier's Beaked Whale	0	0	0	0	0	0	0
Dwarf Sperm Whale	12	14	0	0	0	0	0
False Killer Whale	0	0	0	0	0	0	0
Fin Whale	0	0	0	0	0	0	0
Fraser's Dolphin	0	0	0	0	0	0	0
Ginkgo-toothed Beaked Whale	0	0	0	0	0	0	0
Humpback Whale	0	0	0	0	0	0	0
Killer Whale	0	0	0	0	0	0	0
Longman's Beaked Whale	0	0	0	0	0	0	0
Melon-headed Whale	0	0	0	0	0	0	0
Omura's Whale	0	0	0	0	0	0	0
Pantropical Spotted Dolphin	0	0	0	0	0	0	0
Pygmy Killer Whale	0	0	0	0	0	0	0
Pygmy Sperm Whale	3	4	0	0	0	0	0
Risso's Dolphin	0	0	0	0	0	0	0
Rough Toothed Dolphin	0	0	0	0	0	0	0
Sei Whale	0	0	0	0	0	0	0
Short-finned Pilot Whale	0	0	0	0	0	0	0
Sperm Whale	0	0	0	0	0	0	0
Spinner Dolphin	0	0	0	0	0	0	0
Striped Dolphin	0	0	0	0	0	0	0
Total Predicted Exposures	**15**	**18**	**0**	**0**	**0**	**0**	**0**

[1] There are no predicted exposures from impulse sounds under the No Action Alternative.

Notes: GI = gastrointestinal, PTS = permanent threshold shift, TTS = temporary threshold shift

Dolphins and Small Toothed Whales (Delphinids)

There are no predicted impacts on delphinids from impulse sources (explosions and detonations) associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Conclusion

Testing activities under Alternative 1 and Alternative 2 that use explosives, as described in Table 2.8-2 through Table 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives), generate impulse sound or energy from underwater explosions (see Section 3.0.5.2.1.2,Explosives). There are no testing activities under the No Action Alternative that use explosives. Under Alternative 1 and Alternative 2 testing activities that use explosives may result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of explosives during testing activities under Alternative 1:

- *May expose marine mammals up to 15 times annually to sound or pressure levels that would be considered Level B harassment*

Pursuant to the MMPA, the use of explosives during testing activities under Alternative 2:

- *May expose marine mammals up to 18 times annually to sound or pressure levels that would be considered Level B harassment*

Pursuant to the ESA, the use of explosives during testing activities under Alternative 1 and Alternative 2:

- *May affect, but is not likely to adversely affect blue whale, humpback whale, sei whale, fin whale, and sperm whale*

3.4.4.2.4 Impacts from Swimmer Defense Airguns

Marine mammals could be exposed to sound from swimmer defense airguns during pierside integrated swimmer defense and stationary source testing activities. Swimmer defense airgun testing involves a limited number (up to 100 per event) of impulses from a small (60-cubic-inch [$in.^3$] [983-cubic-centimeter {cm^3}]) airgun. Section 3.0.5.2.1.3 (Swimmer Defense Airguns) provides additional details on the use and acoustic characteristics of swimmer defense airguns.

Activities using swimmer defense airguns were modeled using the Navy Acoustic Effects Model. Model predictions indicate that no marine mammals would be exposed to sound or acoustic energy from swimmer defense airguns that would likely elicit a physiological or behavioral response.

3.4.4.2.4.1 No Action Alternative

Training Activities

Training activities under the No Action Alternative do not include the use of the swimmer defense airguns.

Testing Activities

Testing activities under the No Action Alternative do not include the use of the swimmer defense airguns.

3.4.4.2.4.2 Alternative 1

Training Activities

Training activities under Alternative 1 do not include the use of the swimmer defense airguns.

Testing Activities

Approximately 11 testing activities using swimmer defense airguns would occur annually under Alternative 1.

Pierside integrated swimmer defense testing involves a limited number of impulses from a small airgun in waters of inner Apra Harbor (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-3). The pierside areas where these activities are proposed are inshore, with high levels of activity and therefore elevated levels of ambient noise (Appendix I.3, Sources of Sound). Additionally these areas have low densities of marine mammals. Therefore, auditory masking to marine mammals due to the limited testing of the swimmer defense airgun associated with integrated pierside swimmer defense is unlikely. Airguns would be fired up to 100 times during each activity at an irregular interval as required for the testing objectives. Areas adjacent to Navy pierside locations where these tests would take place are industrialized, and the waterways are open to vessel traffic in addition to military vessels using the pier.

An impulsive sound is generated when the air is almost instantaneously released into the surrounding water, an effect similar to popping a balloon in air. Generated impulses would have short durations, typically a few hundred milliseconds. The root-mean-squared sound pressure level and sound exposure level at a distance 1 m from the airgun would be approximately 200–210 dB re 1 µPa and 185–195 dB re 1 μPa^2-s, respectively. Swimmer defense airguns lack the strong shock wave and rapid pressure increase that would be expected from explosive detonations.

Impulses from swimmer defense airguns could potentially cause temporary hearing loss (i.e., TTS) for animals within a few meters of the sound source. However, TTS is very unlikely given the relatively low source levels, the likelihood marine mammals would avoid the source following the initial impulse, and the implementation of mitigation measures. The Navy Acoustic Effects Model predicted that no marine mammals would be exposed to impulse sounds from swimmer defense airguns at levels capable of causing TTS or PTS. The Navy Acoustic Effects Model also predicted that no marine mammals would be exposed to levels likely to cause meaningful behavioral responses.

The behavioral response of marine mammals to airguns, especially with multiple airguns firing simultaneously and repeating at regular intervals, has been well studied in conjunction with seismic surveys (e.g., oil and gas exploration). Many of these studies are reviewed above in Section 3.4.3.1.2.6 (Behavioral Responses). However, the swimmer defense airgun testing involves the use of only one small (60 $in.^3$ [983 cm^3]) airgun firing a limited number of times, so reactions from marine mammals would likely be much less than what is noted in studies of marine mammal reactions during large-scale seismic studies. Furthermore, the swimmer defense airgun has limited overall use throughout the year. Behavioral impacts on marine mammals are not expected from testing of the swimmer defense airgun.

Marine mammals listed under the ESA are unlikely to enter Apra Harbor where swimmer defense testing of airguns would take place; therefore it is highly unlikely that any ESA-listed marine mammals would be exposed to impulse sounds from swimmer defense airguns.

Pursuant to the MMPA, impulse sounds from swimmer defense airguns during testing activities under Alternative 1 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, impulse sounds from swimmer defense airguns:
- *Would have no effect on blue whale, humpback whale, sei whale, fin whale, and sperm whale*

3.4.4.2.4.3 Alternative 2

Training Activities

Training activities under Alternative 2 do not include the use of the swimmer defense airguns.

Testing Activities

Approximately 11 testing activities using swimmer defense airguns would occur annually under Alternative 2. Under Alternative 2, the annual testing activities involving the use of the swimmer defense airguns are the same as the testing activities proposed under Alternative 1.

Pursuant to the MMPA, impulse sounds from swimmer defense airguns during testing activities under Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, impulse sounds from swimmer defense airguns:
- *Would have no effect on blue whale, humpback whale, sei whale, fin whale, and sperm whale*

3.4.4.2.5 Impacts from Weapons Firing, Launch, and Impact Noise

Marine mammals may be exposed to weapons firing and launch noise and sound from the impact of non-explosive ordnance on the water's surface. A detailed description of these stressors is provided in Section 3.0.5.2.1.4 (Weapons Firing, Launch, and Impact Noise). Reactions by marine mammals to these specific stressors have not been recorded, however marine mammals would be expected to react to weapons firing, launch, and non-explosive impact noise as they would other transient sounds (see Section 3.4.3.1.2.5, Behavioral Responses).

3.4.4.2.5.1 No Action Alternative

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, training activities under the No Action Alternative include activities that produce in water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface. Noise associated with weapons firing and the impact of non-explosive practice munitions could happen at any location within the Study Area but generally would occur at locations greater than 12 nm (and for some activities greater than 25 nm or 50 nm) from shore for safety reasons (see Chapter 2, Description of Proposed Action and Alternatives, and Table 2.8-1). The majority of training activities that would involve weapons firing and ordnance impacts with the water's surface are included in the Primary Mission Areas of anti-surface warfare, major training activities, and mine warfare.

Anti-surface warfare activities and anti-air warfare (surface-to-air) activities would involve the use of non-explosive and explosive ordnance such as small-, medium-, and large-caliber projectiles; missiles; rockets; and bombs. The majority of these activities are gunnery exercises involving the use of small- and medium-caliber rounds. Thirteen major training activities would also occur under the No Action Alternative annually. Some anti-air warfare activities involve weapons firing; however, the majority would occur at altitudes well above the water's surface and would be unlikely to generate noise that would affect marine mammals. Effects to marine mammals from impulse sources (e.g., explosives) are analyzed in Section 3.4.4.2 (Impacts from Impulse Sources [Explosives and Detonations]).

A gun fired from a ship on the surface of the water propagates a blast wave away from the gun muzzle into the water (see Section 3.0.5.2.1.4, Weapons Firing, Launch, and Impact Noise). Average peak sound pressure in the water measured directly below the muzzle of the gun and under the flight path of the shell (assuming it maintains an altitude of only a few meters above the water's surface) was approximately 200 dB re 1 µPa (U.S. Department of the Navy 2000; Yagla and Stiegler 2003). Animals at the surface of the water, in a narrow footprint under a weapons trajectory, could be exposed to naval gunfire noise and may exhibit brief startle reactions, avoidance, diving, or no reaction at all. Due to the short-term, transient nature of gunfire noise, animals are unlikely to be exposed multiple times within a short period. Behavioral reactions would likely be short-term (minutes) and are unlikely to lead to substantial costs or long-term consequences for individuals or populations.

Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange. These sounds would be transient and of short duration, lasting no more than a few seconds at any given location. Many missiles and targets are launched from aircraft, which would produce minimal noise in the water due to the altitude of the aircraft at launch. Missiles and targets launched by ships or near the water's surface may expose marine mammals to levels of sound that could produce brief startle reactions, avoidance, or diving. Due to the short-term, transient nature of launch noise, animals are unlikely to be exposed multiple times within a short period. Behavioral reactions would likely be short-term (minutes) and are unlikely to lead to long-term consequences for individuals or populations.

Mines, non-explosive bombs, and intact missiles and targets could impact the water's surface with great force and produce a large impulse and loud noise (see Section 3.0.5.2.1.4, Weapons Firing, Launch, and Impact Noise). Marine mammals within a few meters could experience some temporary hearing loss, although the probability is low of the non-explosive ordnance landing within this range while a marine mammal is near the surface. Animals that are within the area may hear the impact of non-explosive ordnance on the surface of the water and would likely alert, startle, dive, or flee the immediate area. Significant behavioral reactions from marine mammals would not be expected due to non-explosive ordnance water-surface impact noise, therefore long-term consequences for the individual and population are unlikely.

Mitigation measures implemented by the Navy (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) are designed to reduce potential impacts from the firing of large caliper (5-inch [in.] gun) weapons and certain non-explosive ordnance (non-explosive bombs and mine shapes) water-surface impact associated with the proposed military training activities. Long-term consequences to individuals or populations of marine mammals are not expected to result from weapons firing, launch, and non-explosive ordnance water-surface impact associated with the proposed training events.

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise from training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Tables 2.8-2 to 2.8-4, there are no testing activities that would produce weapons firing, launch, and impact noise proposed under the No Action Alternative.

3.4.4.2.5.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. Under Alternative 1, the number of annual activities that involve weapons firing would increase over the No Action Alternative. Even with an increase in the level of activity under Alternative 1, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.5.1 (No Action Alternative – Training).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. Testing activities that produce in-water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface would occur under Alternative 1 and would increase over the No Action Alternative, because there are no testing activities that use weapons or other ordnance under the No Action Alternative (see Chapter 2, Description of Proposed Action and Alternatives, and Tables 2.8-2 to 2.8-4).

The majority of testing activities that would involve weapons firing and ordnance impacts with the water's surface are Air-to-Surface Missile Test, Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoy), Anti-Surface Warfare Mission Package Testing, and Kinetic Energy Weapon Testing (see Chapter 2, Description of Proposed Action and Alternatives, and Tables 2.8-2 and 2.8-3).

These activities would use both non-explosive and explosive medium-caliber rounds, large-caliber projectiles, and missiles. Impacts from impulse sources (e.g., explosives) are analyzed in Section 3.4.4.2 (Impacts from Impulse Sources [Explosives and Detonations]). Although the activities proposed under Alternative 1 increase over the No Action Alternative, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.5.1 (No Action Alternative – Training).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.5.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. Proposed training activities under Alternative 2 are nearly identical to training activities proposed under Alternative 1 (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-1).

The locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.5.1 (No Action Alternative – Training) and Section 3.4.4.2.5.2 (Alternative 1 – Training).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. The number of testing activities proposed under Alternative 2 is approximately a 10 percent increase over the number of testing activities proposed under Alternative 1. Even with the increase in the number of activities proposed under Alternative 2, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.5.2 (Alternative 1 – Testing).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.6 Impacts from Vessel Noise

Marine mammals may be exposed to noise from vessel movement. A detailed description of the acoustic characteristics and typical sound levels of vessel noise is provided in Section 3.0.5.2.1.5 (Vessel Noise). Vessel movements involve transits to and from ports to various locations within the Study Area, and many ongoing and proposed training and testing activities within the Study Area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels).

Several studies have shown that marine mammals may abandon inshore and nearshore habitats with high vessel traffic, especially in areas with regular marine mammal watching (see discussion in Section 3.4.3.1.2.5, Behavioral Responses). Vessel traffic in the Mariana Islands and the Study Area is considerably less than in other U.S. ports where a larger population and greater commercial commerce occurs (Section 3.12, Socioeconomics). As discussed in Section 3.0.5.2.1.5 (Vessel Noise) Navy ships make up only a small proportion of the total ship traffic. According to Mintz and Filadelfo (2011), Navy ships account for 6 percent of the total ship presence within the U.S. EEZ. Although the study did not include analysis of vessel traffic and associated vessel noise in Guam and the CNMI (the geographic scope was the continental United States and Hawaii), the conclusions of the study are relevant to vessel noise in the Study Area. The study concluded that the contribution of Navy vessel traffic to overall broadband noise levels was relatively small compared with the contribution from commercial vessel traffic. Even during times of heavy military activity, such as during major training activities in military operating areas, and despite being a major presence, military vessels are a relatively minor source of radiated broadband noise. This is because military ships are generally quieter than commercial vessels of similar size (Mintz and Filadelfo 2011).

Even in the most concentrated U.S. ports and inshore areas, proposed military vessel transits are unlikely to cause long-term abandonment of habitat by a marine mammal. Most documented examples of abandonment of habitat are in association with activities that involve the pursuit of marine mammals (Section 3.4.3.1.2.5, Behavioral Responses). The military will not be pursuing marine mammals during any training and testing activities.

Auditory masking can occur due to vessel noise, potentially masking vocalizations and other biologically important sounds (e.g., sounds of prey or predators) that marine mammals may rely upon. Marine mammals have been recorded in several instances altering and modifying their vocalizations to compensate for the masking noise from vessels or other sources of acoustic energy. Potential masking from a transiting vessel can vary depending on the ambient noise level within the environment (see Appendix H.1, Conceptual Framework for Assessing Effects from Sound Producing Activities); the received level and frequency of the vessel noise; and the received level and frequency of the sound of biological interest. In the open ocean, ambient noise levels are between about 60 and 80 dB re 1 µPa, primarily at lower frequencies (below 100 Hz). Inshore noise levels, especially around busy ports, can exceed 120 dB re 1 µPa (Urick 1983). When the noise level is above the sound of interest, and in a similar frequency band, auditory masking could occur (see Appendix H, Biological Resource Methods). This analysis assumes that any sound that is above ambient noise levels and within an animal’s hearing range may potentially cause masking of biologically important sounds. The degree to which a biologically important sound is masked increases with increasing noise levels; an anthropogenic sound that is just-detectable over ambient noise levels is unlikely to actually cause any substantial masking. Masking caused by noise from passing vessels or other sources of acoustic energy (e.g., sonar) would be short-term, intermittent, and therefore unlikely to result in any substantial costs or consequences to individual animals or populations. Areas with increased levels of ambient noise from anthropogenic sound sources, such as areas around busy shipping lanes and near harbors and ports, may cause sustained levels of auditory masking for marine mammals, which could reduce an animal's ability to find prey, find mates, socialize, avoid predators, or navigate. However, military vessels make up a very small percentage of the overall vessel traffic, and the rise of ambient noise levels in shipping lanes and near harbors and ports is a problem related to all ocean users including commercial and recreational vessels and shoreline development and industrialization.

Surface combatant ships (e.g., guided missile destroyer, guided missile cruiser, and Littoral Combat Ship) and submarines are designed to be very quiet to evade enemy detection and typically travel at speeds of 10 or more knots (5.1 m/second). Actual acoustic signatures and source levels of combatant ships and submarine are classified, however they are quieter than most other motorized ships. A typical commercial fishing vessel produces about 158 dB re 1 µPa at 1 m (see Section 3.0.5.2.1.5, Vessel Noise, for a description of typical noise from commercial and recreational vessels). Even with technology intended to limit sound emission, surface combatant ships and submarines still produce noise and are likely to be detectable by marine mammals over open-ocean ambient noise levels (discussed in Section H.1, Conceptual Framework for Assessing Effects from Sound Producing Activities) at distances of up to a few kilometers, which could cause some auditory masking to marine mammals for a few minutes as the vessel passes. Other military ships and small craft have higher noise levels, similar to equivalently sized commercial ships and private vessels. Therefore, in the open ocean, away from relatively noisy shipping lanes, noise from non-combatant Navy vessels may be detectable over ambient noise levels for tens of kilometers and some auditory masking, especially for mysticetes, is possible. In noisier inshore areas around Navy ports and ranges, vessel noise may be detectable above ambient noise levels for only several hundred meters. Some auditory masking to marine mammals is likely from non-combatant military vessels, on par with similar commercial and recreational vessels, especially in quieter, open-ocean environments.

Vessel noise has the potential to disturb marine mammals and elicit an alerting, avoidance, or other behavioral reaction. Most studies have reported that marine mammals react to vessel noise and traffic with short-term interruption of behavior or social interactions (Watkins 1981; Richardson et al. 1995; Magalhães et al. 2002; Noren et al. 2009). Some species respond negatively by retreating or responding to the vessel antagonistically, while other animals seem to ignore vessel noises altogether (Watkins 1986). Marine mammals are frequently exposed to vessels due to research, ecotourism, commercial and private vessel traffic, and government activities. It is difficult to differentiate between responses to vessel noise and visual cues associated with the presence of a vessel; thus, it is assumed that both play a role in prompting reactions from animals.

Based on studies on a number of species, mysticetes are not expected to be disturbed by vessels that maintain a reasonable distance from them; however, behavioral responses will vary with vessel size, geographic location, and tolerance levels of individuals.

Odontocetes could have a variety of reactions to passing vessels including attraction, increased travelling time, a decrease in feeding behaviors, diving, or avoidance of the vessel, which may vary depending on their prior experience with vessels. Passive acoustic monitoring of marine mammal vocalizations at the Navy's instrumented ranges in Hawaii and the Bahamas have documented the presence of beaked whales on the ranges (Marques et al. 2009). Site fidelity of Cuvier's beaked whales was documented by Falcone et al. (2009) at the Navy's instrumented range offshore of San Diego in Southern California. The passive acoustic monitoring and photo-identification study recorded 37 groups of Cuvier's beaked whales from 2006 to 2008, and the researchers reported that the average group size was higher than had previously been reported. Additional behavioral response studies (Aguilar de Soto et al. 2006; Tyack et al. 2011; Southall et al. 2012b) have indicated that while beaked whales exposed to vessel and other anthropogenic noise will change behavior and leave the immediate area of the noise source, within 2–3 days they have re-inhabited the previously vacated areas.

3.4.4.2.6.1 No Action Alternative

Training Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.6 (No Action Alternative: Current Military Readiness within the MITT Study Area), training activities under the No Action Alternative include vessel movement in many events. Military vessel traffic could occur anywhere within the Study Area.

Under the No Action Alternative, approximately 600 training activities involving vessel movement would occur annually and would generate some level of vessel noise.

Military vessel traffic related to the proposed training activities would pass near marine mammals only on an incidental basis, and would constitute an insignificant contribution to vessel traffic in the Study Area. Marine mammals exposed to a passing military vessel may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to vessels are not likely to disrupt major behavioral patterns or to result in serious injury to any marine mammals. Acoustic masking may occur due to vessel sounds, especially from non-combatant ships. Acoustic masking may prevent an animal from perceiving biologically relevant sounds during the period of exposure, potentially resulting in missed opportunities to exploit resources.

Navy mitigation measures include several provisions to avoid approaching marine mammals (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring, for a detailed description of mitigation measures) which would further reduce any potential impacts from vessel noise. Long-term consequences to individuals or populations of marine mammals are not expected to result from vessel noise associated with the proposed training events.

Pursuant to the MMPA, vessel noise during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), only one testing activity is proposed under the No Action Alternative (Table 2.8-4). The Office of Naval Research's North Pacific Acoustic Lab deep water experiment would occur once per year. This activity could take place anywhere within the Study Area where conditions (e.g., water depth) meet the requirements of the activity. The number of proposed testing activities under the No Action Alternative that involve vessel movement is fewer than the number of proposed training activities under the No Action Alternative, described above in Section 3.4.4.2.6.1 (No Action Alternative – Training). No long-term consequences are anticipated from the training activities, which would involve more vessel traffic; therefore, no long-term consequences to individuals or populations of marine mammals are expected to result from vessel noise associated with the proposed testing event.

Pursuant to the MMPA, vessel noise during testing activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during testing activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.6.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As discussed in Chapter 2 (Description of Proposed Action and Alternatives), training activities under Alternative 1 include an increase in the number of activities that would involve vessel movement over the No Action Alternative.

Under Alternative 1, approximately 2,500 training activities involving vessel movement would occur annually and would generate some level of vessel noise. This represents an increase in activity of approximately 300 percent over the No Action Alternative.

Military vessel traffic related to the proposed training activities would pass near marine mammals only on an incidental basis and would constitute an insignificant contribution to vessel traffic in the Study Area. Marine mammals exposed to a passing military vessel may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to vessels are not likely to disrupt major behavioral patterns or to result in serious injury to any marine mammals. Acoustic masking may occur due to vessel sounds, especially from non-combatant ships. Acoustic masking may prevent an animal from perceiving biologically relevant sounds during the period of exposure, potentially resulting in missed opportunities to exploit resources.

Some training activities involving vessel movement have the potential to occur, at least partially, in nearshore or littoral waters of the Study Area (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-1). It is possible, although unlikely, that these activities may occur in proximity to spinner dolphin resting areas identified in Section 3.4.2.23.2 (Spinner Dolphin, Geographic Range and Distribution). Several of these training activities occur infrequently (1–4 times per year). Other training activities would occur in nearshore areas where non-military activities also occur (e.g., Apra Harbor), which are unlikely to be spinner dolphin resting areas. To date, there have been no sightings of spinner dolphins in Apra Harbor.

Mitigation, as described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), for activities occurring in offshore and nearshore areas of the Study Area would include surveying for marine mammals, including resting spinner dolphins, prior to conducting the activity. Given that nearshore activities occur infrequently, they would be unlikely to occur in the vicinity of spinner dolphin resting areas, and mitigation to avoid potential effects would be conducted, no long-term consequences to spinner dolphins, such as habitat abandonment, are anticipated.

The number of training activities that involve vessel movement (and vessel noise) under Alternative 1 would increase over the number proposed under the No Action Alternative; however, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.6.1 (No Action Alternative – Training).

Pursuant to the MMPA, vessel noise during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As discussed in Chapter 2 (Description of Proposed Action and Alternatives, Tables 2.8-3 and 2.8-4), testing activities under Alternative 1 include an increase in vessel movement over the No Action Alternative.

Only one testing activity is proposed under the No Action Alternative. Under Alternative 1, approximately 159 testing activities involving vessel movement would occur annually and would generate some level of vessel noise.

The number of testing activities that involve vessel movement (and vessel noise) under Alternative 1 would increase over the number proposed under the No Action Alternative; however, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.6.1 (No Action Alternative – Training).

Pursuant to the MMPA, vessel noise during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.6.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities, which includes the addition of platforms and systems. As discussed in Chapter 2 (Description of Proposed Action and Alternatives, Tables 2.8-1), training activities under Alternative 2 include an increase in vessel movement over the No Action Alternative and Alternative 1.

Under Alternative 2, approximately 2,600 training activities involving vessel movement would occur annually and would generate some level of vessel noise. This represents an increase in activity of approximately 300 percent over the No Action Alternative, and is nearly equivalent to Alternative 1.

Military vessel traffic related to the proposed training activities would pass near marine mammals only on an incidental basis and would constitute an insignificant contribution to vessel traffic in the Study Area. Marine mammals exposed to a passing military vessel may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to vessels are not likely to disrupt major behavioral patterns or to result in serious injury to any marine mammals. Acoustic masking may occur due to vessel sounds, especially from non-combatant ships. Acoustic masking may prevent an animal from perceiving biologically relevant sounds during the period of exposure, potentially resulting in missed opportunities to exploit resources.

Some training activities involving vessel movement have the potential to occur, at least partially, in nearshore or littoral waters of the Study Area (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-1). It is possible, although unlikely, that these activities may occur in proximity to spinner dolphin resting areas identified in Section 3.4.2.23.2 (Spinner Dolphin, Geographic Range and Distribution). Several of these training activities occur infrequently (1–4 times per year). Other training activities would occur in nearshore areas where non-military activities also occur (e.g., Apra Harbor), which are unlikely to be spinner dolphin resting areas. To date, there have been no sightings of spinner dolphins in Apra Harbor.

Mitigation, as described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) for activities occurring in offshore and nearshore areas of the Study Area would include surveying for marine mammals, including resting spinner dolphins, prior to conducting the activity. Given that nearshore activities occur infrequently, would be unlikely to occur in the vicinity of spinner dolphin resting areas, and mitigation to avoid potential effects would be conducted, no long-term consequences to spinner dolphins, such as habitat abandonment, are anticipated.

The number of training activities that involve vessel movement (and vessel noise) under Alternative 1 would increase over the number proposed under the No Action Alternative; however, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.6.1 (No Action Alternative – Training).

Pursuant to the MMPA, vessel noise during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. Testing activities under Alternative 2 include an increase in vessel movement over the No Action Alternative and Alternative 1.

The number of proposed testing activities that involves vessel movement increases from 1 under the No Action Alternative to 187 under Alternative 2 (Chapter 2, Description of Proposed Action and Alternatives, Tables 2.8-3 and 2.8-4). The 187 testing activities involving vessel movement represent less than a 20 percent increase over the number of testing activities proposed under Alternative 1.

The number of testing activities that involve vessel movement (and vessel noise) under Alternative 2 would increase over the number proposed under the No Action Alternative and Alternative 1; however, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.6.1 (No Action Alternative – Training).

Pursuant to the MMPA, vessel noise during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.7 Impacts from Aircraft Noise

Marine mammals may be exposed to aircraft-generated noise wherever aircraft overflights occur in the Study Area. Fixed and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area. Most of these sounds would be concentrated around airbases and fixed ranges within each of the range complexes. Aircraft can produce extensive airborne noise from either turbofan or turbojet engines. A severe but infrequent type of aircraft noise is a sonic boom, produced when a fixed-wing aircraft (e.g., F/A-18 fighter jet) exceeds the speed of sound. Rotary-wing aircraft (helicopters) produce low-frequency sound and vibration (Pepper et al. 2003). A detailed description of aircraft noise as a stressor (including sonic booms) is provided in Section 3.0.5.2.1.6 (Aircraft Overflight Noise).

3.4.4.2.7.1 No Action Alternative

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), training activities under the No Action Alternative include fixed- and rotary-wing aircraft overflights. More than 5,300 training activities involving some level of aircraft activity are proposed under the No Action Alternative.

Marine mammals may respond to both the physical presence and to the noise generated by aircraft, making it difficult to attribute causation to one or the other stimulus. In addition to noise produced, all low-flying aircraft make shadows, which can cause animals at the surface to react. Helicopters may also produce strong downdrafts, a vertical flow of air that becomes a surface wind, which can also affect an animal's behavior at or near the surface.

Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors, but significant acoustic energy is primarily transmitted into the water directly below the craft in a narrow cone, as discussed in greater detail in Section 3.0.4 (Acoustic and Explosives Primer). Underwater sounds from aircraft are strongest just below the surface and directly under the aircraft. The maximum sound levels at 6 ft. (2 m) below the surface from an aircraft overflight are approximately 152 dB re 1 µPa for an F/A-18 aircraft at 300 m altitude; approximately 125 dB re 1 µPa for an H-60 helicopter hovering at 50 ft. (15 m); and under ideal conditions, sonic booms from aircraft at an altitude of approximately 1 km could generate a SPL of 178 dB re 1 µPa at the water's surface (see Section 3.0.5.2.1.6, Aircraft Overflight Noise), for additional information on aircraft noise characteristics).

See Section 3.4.3.1.2.5 (Behavioral Responses), for a review of research and observations regarding marine mammal behavioral reactions to aircraft overflights; many of the observations cited in this section are of marine mammal reactions to aircraft flown for whale-watching and marine research purposes. Marine mammal survey aircraft are typically used to locate, photograph, track, and sometimes follow animals for long distances or for long periods of time, all of which results in the animal being much more frequently located directly beneath the aircraft (in the cone of the loudest noise and in the shadow of the aircraft) for extended periods. Navy aircraft would not follow or pursue marine mammals. In contrast to whale watching excursions or research efforts, Navy overflights would not result in prolonged exposure of marine mammals to overhead noise.

Most fixed-wing military aircraft flights would occur above 3,000 ft. (900 m), and often at much higher altitudes (e.g., 20,000 ft. [6,000 m]) in the Study Area. Rotary wing aircraft typically fly at lower altitudes (less than 1,000 ft. [100 m]) and may hover at less than 100 ft. (30 m) during certain training and testing activities. In most cases, exposure of a marine mammal to fixed-wing or rotary-wing aircraft presence and noise would last for only seconds as the aircraft quickly passes overhead. Animals would have to be at or near the surface at the time of an overflight to be exposed to appreciable sound levels. Takeoffs and landings occur at established airfields as well as on vessels at sea at unspecified locations across the Study Area. Takeoff and landings from Navy vessels could startle marine mammals; however, these events only produce in-water noise at any given location for a brief period of time as the aircraft climbs to cruising altitude. As discussed in Section 3.0.5.2.1.6 (Aircraft Overflight Noise), marine mammals show little to no reaction from aircraft overflights above 2,000 ft. (600 m). Some sonic booms from aircraft could startle marine mammals, but these events are transient and happen infrequently at any given location within the Study Area. Repeated exposure to most individuals over short periods (days) is extremely unlikely. No long-term consequences for individuals or populations would be expected.

Low flight altitudes of helicopters during some anti-submarine warfare and mine warfare activities, often under 100 ft. (30 m), may elicit a somewhat stronger behavioral response due to the proximity to marine mammals; the slower airspeed and therefore longer exposure duration; and the downdraft created by the helicopter's rotor. Marine mammals would likely avoid the area under the helicopter. It is unlikely that an individual would be exposed repeatedly for long periods of time as these aircraft typically transit open ocean areas within the Study Area. The consensus of all the studies reviewed is that aircraft noise would cause only small temporary changes in the behavior of marine mammals. Specifically, marine mammals located at or near the surface when an aircraft flies overhead at low altitudes may startle, divert their attention to the aircraft, or avoid the immediate area by swimming away or diving.

Under the No Action Alternative, the number of overflights, typical altitudes, and distribution throughout the year and over the Study Area would result in a low probability of exposing marine mammals to aircraft noise. Even if a mysticete or odontocete were exposed to overflight noise, no long-term consequences to the individual or populations of marine mammals would be anticipated. Short-term reactions to aircraft are not likely to disrupt major behavior patterns such as migrating, breeding, feeding, and sheltering, or to result in serious injury to any marine mammals. No long-term consequences for individuals or populations would be expected.

Pursuant to the MMPA, aircraft overflight noise during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, aircraft overflight noise during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), there are no proposed testing activities using aircraft under the No Action Alternative (see Tables 2.8-2 to 2.8-4).

3.4.4.2.7.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. Under Alternative 1, more than 19,600 aircraft-related activities would occur throughout the Study Area. This represents an increase in activity of approximately 300 percent over the No Action Alternative.

Neither the locations nor the flight profiles (altitude, airspeed, and duration) would change between the No Action Alternative and Alternative 1. Even with an increase in the number of aircraft overflights, the majority of flight time would occur at altitudes greater than 3,000 ft. above the water's surface. As discussed in Section 3.4.4.2.7.2 (No Action Alternative – Training) marine mammals are unlikely to be disturbed by high altitude overflights. Therefore, the severity of impacts would not be discernible from those described in Section 3.4.4.2.7.2 (No Action Alternative – Training).

Pursuant to the MMPA, aircraft overflight noise during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, aircraft overflight noise during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. Under Alternative 1, up to 390 aircraft-related testing activities would occur throughout the Study Area.

The locations and flight profiles (altitude, airspeed, and duration) of testing activities involving aircraft would be similar to training activities involving aircraft. Even with an increase in the number of aircraft overflights, the majority of flight time would occur at altitudes greater than 3,000 ft. (914.4 m) above the water's surface. As discussed in Section 3.4.4.2.7.2 (No Action Alternative – Training) marine mammals are unlikely to be disturbed by high altitude overflights. Therefore, the severity of impacts would not be discernible from those described in Section 3.4.4.2.7.2 (No Action Alternative – Training).

Pursuant to the MMPA, aircraft overflight noise during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, aircraft overflight noise during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.7.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities.

Under Alternative 2, more than 21,000 aircraft-related training activities would occur throughout the Study Area. This represents an increase in activity of approximately 300 percent over the No Action Alternative, and is approximately equivalent to the level of activity proposed under Alternative 1.

Neither the locations nor the flight profiles (altitude, airspeed, and duration) would change between the No Action Alternative and Alternative 1. Even with an increase in the number of aircraft overflights, the majority of flight time would occur at altitudes greater than 3,000 ft. (914.4 m) above the water's surface. As discussed in Section 3.4.4.2.7.2 (No Action Alternative – Training) marine mammals are unlikely to be disturbed by high altitude overflights. Therefore, the severity of impacts would not be discernible from those described in Section 3.4.4.2.7.2 (No Action Alternative – Training).

Pursuant to the MMPA, aircraft overflight noise during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, aircraft overflight noise during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities, which includes the addition of platforms and systems.

Under Alternative 2, up to 436 aircraft-related testing activities would occur throughout the Study Area. This represents approximately a 10 percent increase over the level of activity proposed under Alternative 1.

Neither the locations nor the flight profiles (altitude, airspeed, and duration) would change from Alternative 1. Even with an increase in the number of aircraft overflights, the majority of flight time would occur at altitudes greater than 3,000 ft. (914.4 m) above the water's surface. As discussed in Section 3.4.4.2.7.2 (No Action Alternative – Training) marine mammals are unlikely to be disturbed by high altitude overflights. Therefore, the severity of impacts would not be discernible from those described in Section 3.4.4.2.7.2 (No Action Alternative – Training).

Pursuant to the MMPA, aircraft overflight noise during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, aircraft overflight noise during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.3 Energy Stressors

This section analyzes the potential impacts of energy stressors used during training and testing activities within the Study Area. The detailed analysis which follows includes the potential impacts of devices that purposefully create an electromagnetic field underwater (e.g., some mine neutralization systems; see Section 2.3.5, Mine Warfare Systems).

Two types of devices proposed for use in the Study Area that have the potential to be energy stressors are lasers and the kinetic energy weapon. However, neither device is analyzed as a potential biological stressor. Laser devices can be organized into two categories: (1) high-energy lasers and (2) low-energy lasers. High-energy lasers are used as weapons to disable surface targets (e.g., small boats). High-energy lasers are not proposed for use in the Study Area, and will not be discussed further. Low-energy lasers are used to illuminate or designate targets, to guide weapons, and to detect or classify mines. Low-energy lasers were briefly analyzed in Section 3.0.5.2.2.2 (Lasers) and were determined to have no impacts to biological resources, including marine mammals, and will not be analyzed further. The kinetic energy weapon (commonly referred to as the rail gun) is under development and will likely be tested and eventually used in training events aboard surface vessels, firing non-explosive projectiles at sea-based targets. The system uses stored electrical energy to accelerate the projectile, which is fired at supersonic speeds over great distances. The system charges for 2 minutes and fires in less than 1 second; therefore, any electromagnetic energy released would be done over a very short time period. Also, the system would be shielded so as not to affect shipboard controls and systems. The amount of electromagnetic energy released from this system would likely be low and contained on the surface vessel. Therefore, this device is not expected to result in any impacts to marine mammals.

3.4.4.3.1 Impacts from Electromagnetic Devices

For a discussion of the types of activities that purposefully create an electromagnetic field underwater, where these activities would occur, and how many events would occur under each alternative, refer to Section 3.0.5.2.2.1 (Electromagnetic Devices).

The devices producing an electromagnetic field (and analyzed in this section) are towed mine countermeasure systems. These systems use electric current to generate a magnetic field, which simulates a vessel's magnetic field. In an actual mine clearing operation, the magnetic field would trigger an enemy mine designed to sense a vessel's magnetic field.

Neither regulations nor scientific literature provide threshold criteria for assessing potential effects from the generation of a magnetic field. Data regarding the influence of magnetic fields on cetaceans are inconclusive. Dolman et al. (2003) provides a literature review of the influences on cetaceans of marine wind farms, which use undersea cables to transmit electrical current to shore. The electrical current conducted by undersea power cables induces a magnetic field around those cables. The literature focuses on harbor porpoises and dolphin species, because these species are found in nearshore habitats. Teilmann et al. (2002) evaluated the frequency of harbor porpoise presence at wind farm locations around Sweden. Although the influence of the electromagnetic field was not specifically addressed, the presence of cetacean species at least implies that those species are not repelled by the presence of a magnetic field around undersea cables associated with offshore wind farms.

Based on the available literature, no evidence of electrosensitivity in marine mammals was found except recently in the Guiana dolphin (Czech-Damal et al. 2011). Normandeau et al. (2011) concluded there was behavioral, anatomical, and theoretical evidence indicating cetaceans sense magnetic fields. Most of the evidence in this regard is indirect evidence from correlation of sighting and stranding locations suggesting that cetaceans may be influenced by local variation in the earth's magnetic field (Hui 1985: Kirschvink 1990; Klinowska 1985; Walker et al. 1992). Results from one study in particular showed that long-finned and short-finned pilot whales, striped dolphin, Atlantic spotted dolphin, Atlantic white-sided dolphin, fin whale, common dolphin, harbor porpoise, sperm whale, and pygmy sperm whale were found to strand in areas where the earth's magnetic field was locally weaker than surrounding areas (negative magnetic anomaly) (Kirschvink 1990). Results also indicated that certain species may be able to detect total intensity changes of only 0.05 microtesla (0.05×10^{-6} tesla) (Kirschvink et al. 1986). The Tesla is the unit of measure for the intensity or magnitude of a magnetic field. For reference, the magnetic field near a small bar magnet is approximately 0.1 tesla (Halliday and Resnick 1988). This gives insight into what changes in intensity levels some species are capable of detecting, but does not provide experimental evidence of levels to which animals may physiologically or behaviorally respond.

Anatomical evidence suggests the presence of magnetic material in the brain of some marine mammals (i.e., bottlenose dolphin, Cuvier's beaked whale, and the humpback whale) and in the tongue and lower jawbones of harbor porpoise (Bauer et al. 1985; Kirschvink 1990). Zoeger et al. (1981) found what appeared to be nerve fibers associated with the magnetic material in a Pacific common dolphin (*Delphinus* spp.) and proposed that it may be used as a magnetic field receptor. The only experimental study involving physiological response comes from Kuznetsov (1999), who exposed bottlenose dolphins to permanent magnetic fields and showed reactions (both behavioral and physiological) to magnetic field intensities of 32, 108 and 168 microteslas during 79 percent, 63 percent, and 53 percent of the trials, respectively (as summarized in Normandeau et al. 2011). Behavioral reactions of bottlenose dolphins included sharp exhalations, acoustic activity, and movement, and physiological reactions included a change in heart rate.

Potential impacts to marine mammals associated with magnetic fields are dependent on the animal's proximity to the source and the strength of the magnetic field. As discussed in Section 3.0.5.2.2.1 (Electromagnetic Devices), electromagnetic fields associated with naval training and testing activities are relatively weak (only 10 percent of the earth's magnetic field at 79 ft. [24 m]), temporary, and localized. Once the source is turned off or moves from the location, the magnetic field is gone. A marine mammal would have to be present within the magnetic field (approximately 700 ft. [200 m] from the source) during the activity in order to detect it.

3.4.4.3.1.1 No Action Alternative

Training Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), there are no training activities that involve the use of electromagnetic devices under the No Action Alternative (Table 2.8-1).

Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), there are no testing activities that involve the use of electromagnetic devices under the No Action Alternative (Table 2.8-2 to Table 2.8-4).

3.4.4.3.1.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

As indicated in Section 3.0.5.2.2.1 (Electromagnetic Devices), training activities involving electromagnetic devices under Alternative 1 occur up to five times annually as part of mine countermeasure (towed mine detection) and Civilian Port Defense activities. Table 2.8-1 lists the number and location of training activities that use electromagnetic devices. These training activities would typically take place in an area designated for mine warfare training located north of Apra Harbor. The easternmost boundary of this area is located approximately 2.4 nm from land, which is the shortest distance between the mine warfare training area and Guam. Training activities would be conducted closer to the center of the area and farther from land.

Although it is not fully understood, based on the available evidence described above, it is probable that cetacea use the earth's magnetic field for movement or migration. If an animal was exposed to the moving electromagnetic field source and if sensitive to that source, it is conceivable that this electromagnetic field could have an effect while in proximity to a cetacean and thereby impacting that animal's navigation. Potential impacts from training with electromagnetic devices would be temporary and minor. The natural behavioral patterns of any affected marine mammals would not be significantly altered or abandoned based on: (1) the relatively low intensity of the magnetic fields generated (discussed above), (2) the very localized affect of the moving electromagnetic field, (3) infrequent occurrence of the stressor, (4) the duration of the mine neutralization activity (hours for shipboard systems; minutes for airborne systems), and (5) this activity typically occurs in waters closer to shore where magnetic fields are less likely to be the primary cue for a cetacean navigating in that environment. For these reasons, it is extremely unlikely that any effects would occur, and if they did their temporary nature would make those effects insignificant. Long-term consequences to individuals or populations of marine mammals are not expected to result from the use of electromagnetic devices.

Pursuant to the MMPA, the use of electromagnetic devices during training activities under Alternative 1 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of electromagnetic devices during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-3, mission package testing for new ship systems includes the use of electromagnetic devices (devices that use electric current to generate magnetic fields for detecting mines). Under Alternative 1, the Naval Sea Systems Command will engage in up to 32 Mine Counter Measure mission package testing activities per year.

As described under Section 3.4.4.3.1.2 (Alternative 1 – Training), it is extremely unlikely that any effects would occur, and if they did their temporary nature would make those effects negligible. Long-term consequences to individuals or populations of marine mammals are not expected to result from the use of electromagnetic devices.

Pursuant to the MMPA, the use of electromagnetic devices during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of electromagnetic devices during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.3.1.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities, which includes platforms and systems. As indicated in Section 3.0.5.2.2.1 (Electromagnetic Devices), training activities involving electromagnetic devices under

Alternative 2 occur up to five times annually as part of mine countermeasure (towed mine detection) and Civilian Port Defense activities. Table 2.8-1 lists the number and location of training activities that use electromagnetic devices.

As described under Section 3.4.4.3.1.2 (Alternative 1 – Training), it is extremely unlikely that any effects would occur, and if they did their temporary nature would make those effects insignificant. Long-term consequences to individuals or populations of marine mammals are not expected to result from the use of electromagnetic devices.

Pursuant to the MMPA, the use of electromagnetic devices during training activities under Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of electromagnetic devices during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-3, mission package testing for new ship systems includes the use of electromagnetic devices (magnetic fields generated underwater to detect mines). Under Alternative 2, the Naval Sea Systems Command will engage in up to 36 Mine Counter Measure mission package testing activities per year.

As described under Section 3.4.4.3.1.2 (Alternative 1 – Training), it is extremely unlikely that any effects would occur, and if they did their temporary nature would make those effects negligible. Long-term consequences to individuals or populations of marine mammals are not expected to result from the use of electromagnetic devices.

Pursuant to the MMPA, the use of electromagnetic devices during testing activities under Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of electromagnetic devices during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.4 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance to include the potential for strike during training and testing activities within the Study Area from (1) Navy vessels, (2) in-water devices, (3) military expended materials to include non-explosive practice munitions and fragments from high-explosive munitions, and (4) seafloor devices.

The way a physical disturbance may affect a marine mammal would depend in part on the relative size of the object, the speed of the object, the location of the mammal in the water column, and reactions of marine mammals to anthropogenic activity, which may include avoidance or attraction. It is not known at what point or through what combination of stimuli (visual, acoustic, or through detection in pressure changes) an animal becomes aware of a vessel or other potential physical disturbances prior to reacting or being struck. Refer to Sections 3.4.4.2.6 (Impacts from Vessel Noise) and 3.4.4.2.7 (Impacts from Aircraft Noise) for the analysis of the potential for disturbance from acoustic stimuli.

If a marine mammal responds to physical disturbance, the individual must stop whatever it was doing and divert its physiological and cognitive attention in response to the stressor. The energetic costs of reacting to a stressor are dependent on the specific situation, but one can assume that the caloric requirements of a response may reduce the amount of energy available to the mammal for other functions, such as reproduction, growth, and homeostasis (Wedemeyer et al. 1990). Given that the presentation of a physical disturbance should be very rare and brief, the cost from the response is likely to be within the normal variation experiences by an animal in its daily routine unless the animal is struck. If a strike does occur, the cost to the individual could range from slight injury to death.

3.4.4.4.1 Impacts from Vessels

Interactions between surface vessels and marine mammals have demonstrated that surface vessels can be a source of acute and chronic disturbance for marine mammals (Hewitt 1985; Watkins 1986; Au and Green 2000; Magalhães et al. 2002; Richter et al. 2003; Nowacek et al. 2004a,b; Bejder et al. 2006; Richter et al. 2006; Nowacek et al. 2007; Würsig and Richardson 2008; Lusseau et al. 2009; Carrillo and Ritter 2010; Glass et al. 2010; Henry et al. 2011; Pace 2011). While the analysis of potential impact form the physical presence of the vessel is presented here, the analysis of potential impacts in response to sounds are addressed in Section 3.4.4.2.6 (Impacts from Vessel Noise).

These studies establish that marine mammals are likely to engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two. Though the noise generated by the vessels is probably an important contributing factor to the responses of cetaceans to the vessels. In one study, North Atlantic right whales were documented to show little overall reaction to the playback of sounds of approaching vessels, but that they did respond to an alert signal by swimming strongly to the surface (Nowacek et al. 2004a). Aside from the potential for an increased risk of collision addressed below, physical disturbance from vessel use is not expected to result in more than a short-term behavioral response.

Vessel speed, size, and mass are all important factors in determining potential impacts of a vessel strike to marine mammals (Silber et al. 2010; Vanderlaan and Taggart 2007; Wiley et al. 2011; Gende et al. 2011; Conn and Silber 2013). For large vessels, speed and angle of approach can influence the severity of a strike. Based on modeling, Silber et al. (2010) found that whales at the surface experienced impacts that increased in magnitude with the ship's increasing speed. Results of the study also indicated that potential impacts were not dependent on the whale's orientation to the path of the ship, but that vessel speed may be an important factor. At ship speeds of 15 knots or higher (7.7 m/second), there was a marked increase in intensity of centerline impacts to whales. Results also indicated that when the whale was below the surface (about one to two times the vessel draft), there was a pronounced propeller suction effect. This suction effect may draw the whale into the hull of the ship, increasing the probability of propeller strikes (Silber et al. 2010).

Vessel strikes from commercial, recreational, and military vessels are known to affect large whales and have resulted in serious injury and occasional fatalities to cetaceans (Lammers et al. 2003; Douglas et al. 2008; Abramson et al. 2009; Laggner 2009; Berman-Kowalewski et al. 2010; National Marine Fisheries Service 2010; Calambokidis 2012). Reviews of the literature on ship strikes mainly involve collisions between commercial vessels and whales (e.g., Laist et al. 2001; Jensen and Silber 2004). The ability of any ship to detect a marine mammal and avoid a collision depends on a variety of factors, including environmental conditions, ship design, size, speed, and manning, as well as the behavior of the animal. Key points in discussions of military vessels in relationship to ship strike include:

- Many military ships have their bridges positioned closer to the bow, offering better visibility ahead of the ship.
- There are often aircraft associated with the training or testing activity, which can often more readily detect marine mammals in the vicinity of a vessel or ahead of a vessel's present course before crew on the vessel would be able to detect them.
- Military ships are generally much more maneuverable than commercial merchant vessels, and if marine mammals are spotted in the path of the ship, would be capable of changing course more quickly. military ships operate at the slowest speed possible consistent with either transit needs or training or testing needs. While minimum speed is intended as a fuel conservation measure particular to a certain ship class, secondary benefits include better ability to spot and avoid objects in the water including marine mammals. In addition, a standard operating procedure for military vessels is to maneuver the vessel to maintain a distance of at least 500 yd. (457 m) from any observed whale and to avoid approaching whales head-on, as long as safety of navigation is not imperiled.
- The crew size on military vessels is generally larger than merchant ships, allowing for the possibility of stationing more trained Lookouts on the bridge. At all times when vessels are underway, trained Lookouts and bridge navigation teams are used to detect objects on the surface of the water ahead of the ship, including marine mammals. Additional Lookouts, beyond those already stationed on the bridge and on navigation teams, are positioned as Lookouts during some training events.
- Military Lookouts receive extensive training including Marine Species Awareness Training, which instructs Lookouts to recognize marine species detection cues (e.g., floating vegetation or flocks of seabirds) as well as provides additional information to aid in the detection of marine mammals.

Submarines, when on the surface, use trained Lookouts serving the same function as they do on surface ships and are thus able to detect and avoid marine mammals. When submerged, submarines are generally slow moving (to avoid detection), and therefore marine mammals at depth with a submarine are likely able to avoid collision with the submarine. The Navy's mitigation measures are detailed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring).

Mysticetes. Vessel strikes have been documented for almost all of the rorqual whale species. This includes blue whales (Berman-Kowalewski et al. 2010; Van Waerebeek et al. 2007; Calambokidis 2012), fin whales (Van Waerebeek et al. 2007, Douglas et al. 2008), sei whales (Felix and Van Waerebeek 2005, Van Waerebeek et al. 2007), Bryde's whales (Felix and Van Waerebeek 2005; Van Waerebeek et al. 2007), minke whales (Van Waerebeek et al. 2007), and humpback whales (Lammers et al. 2003; Van Waerebeek et al. 2007; Douglas et al. 2008).

Odontocetes. In general, odontocetes move quickly and seem to be less vulnerable to vessel strikes than other cetaceans; however, most small whale and dolphin species have at least occasionally suffered from vessel strikes including: killer whale (Van Waerebeek et al. 2007; Visser and Fertl 2000), short-finned and long-finned pilot whales (Aguilar et al. 2000; Van Waerebeek et al. 2007), bottlenose dolphin (Bloom and Jager 1994; Van Waerebeek et al. 2007; Wells and Scott 1997), spinner dolphin

(Camargo and Bellini 2007; Van Waerebeek et al. 2007), striped dolphin (Van Waerebeek et al. 2007), and pygmy sperm whales (*Kogia breviceps*) (Van Waerebeek et al. 2007). Beaked whales documented in vessel strikes include: Cuvier's beaked whale (Aguilar et al. 2000; Van Waerebeek et al. 2007), and several species of *Mesoplodon* beaked whale (Van Waerebeek et al. 2007). However, evidence suggests that beaked whales may be able to hear the low-frequency sounds of large vessels and thus avoid collision (Ketten 1998). Sperm whales may be exceptionally vulnerable to vessel strikes as they spend extended periods of time "rafting" at the surface in order to restore oxygen levels within their tissues after deep dives (Jaquet and Whitehead 1996; Watkins et al. 1999). There were also instances in which sperm whales approached vessels too closely and were cut by the propellers (Aguilar de Soto et al. 2006).

Some training activities may occur, at least partially, in nearshore waters of the Study Area and would have the potential to disturb resting spinner dolphins (see Section 3.4.2.23, Spinner Dolphin, for locations of spinner dolphin resting areas). As shown in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1), portions of three major training exercises (Maritime Homeland Defense/Security Mine Countermeasure Exercise, Marine Air Ground Task Force Exercise [Amphibious], and Special Purpose Marine Air Ground Task Force Exercise) may occur in nearshore or littoral waters. Combined, these exercises would occur seven times per year. In addition, the following training activities involving vessel movement would occur in nearshore waters: the Amphibious Rehearsal, No Landing – Marine Air Ground Task Force training activity (12 times per year); the Limpet Mine Neutralization System/Shock Wave Generator activity (40), Surface Ship Sonar Maintenance (48), Submarine Sonar Maintenance (42), and Submarine Navigation (8). Mitigation, as described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would include surveying for marine mammals, including resting spinner dolphins, prior to conducting the activity. Given that nearshore areas where military activities take place are unlikely to coincide with spinner dolphin resting sites, and mitigation to avoid potential effects would be conducted, vessel strikes on spinner dolphins are not anticipated.

3.4.4.4.1.1 No Action Alternative, Alternative 1, and Alternative 2

<u>Training and Testing Activities</u>

As indicated in Section 3.0.5.2.3.2 (Vessels), most training activities involve the use of vessels. These activities could be widely dispersed throughout the Study Area and the year. Under the three alternatives, the proposed training and testing activities would not result in any appreciable changes from the manner in which the military has trained and would remain consistent with the range of variability observed over the last decade. Consequently, the military does not anticipate vessel strikes will occur within the Study Area under any of the alternatives. The difference in the number of events from the No Action Alternative to Alternative 1 and Alternative 2 is described in Section 3.0.5.2.3.2 (Vessels), and is not likely to change the probability of a vessel strike in any meaningful way.

There are no records of any military vessel strikes to marine mammals in the Study Area. In areas outside the Study Area (e.g., HRC and SOCAL), there have been recorded military vessel strikes of large whales. However, these are areas where the number of military vessels is much higher and training and testing activities occur more often than in the MITT Study Area.

As described above in this section and in Section 3.4.2 (Affected Environment), mysticetes and sperm whales are particularly susceptible to ship strikes. In addition to the greater number of military vessels, the estimated densities of humpback whales, blue whales, and fin whales are at least an order of magnitude higher in the Navy's SOCAL Operating Area than in the MITT Study Area. The density estimates of sperm whales and minke whales in the MITT Study Area are similar to the estimates for SOCAL. Given these disparities, the likelihood of a vessel strike is minimal and far less than in the SOCAL Operating Area.

Because there are no known ship strikes of marine mammals by Navy or U.S. Coast Guard vessels in the MITT Study Area, there are no data to conduct an analysis of the probability of a ship strike based on historical data, as was done for the Hawaii-Southern California Training and Testing EIS/OEIS (U.S. Department of the Navy 2013b). However, 76 sightings of large whales (including sperm whale, humpback whale, sei whale, Bryde's whale, and unidentified large whales) were made during the 2007 Mariana Islands Sea Turtle and Cetacean Survey (MISTCS) (Fulling et al. 2011), and 13 large whales were sighted by Navy Lookouts during a training exercise conducted in the Mariana Islands Range Complex (MIRC) from 16 to 21 September 2010 (U.S. Department of the Navy 2011). While the sightings from MISTCS, a dedicated line transect survey, do not reflect the encounter rate expected for military training and testing activities, the survey results do confirm the presence of large whales in the Study Area. Additionally, the 2011 exercise monitoring report confirms that large whales can be sighted by Navy Lookouts in the vicinity of a military exercise (U.S. Department of the Navy 2011).

In order to account for the accidental nature of a possible ship strike in general, and potential risk from any vessel movement within the Study Area, the military has sought take authorization in the event a military ship strike does occur within the Study Area during the 5-year period of NMFS' final authorization. Given that there are no data from which to estimate the potential for a strike to occur in the Study Area, the military will request authorization for mortality or serious injury from vessel strike to no more than five large whales as a result of training and testing activities over the course of the 5 years of the rulemaking issued by NMFS for the Study Area. This would consist of no more than one large whale in any given year of the following species: fin whale, blue whale, humpback whale, Bryde's whale, Omura's whale, sei whale, minke whale, or sperm whale.

Pursuant to the MMPA, the use of vessels during training and testing activities under the No Action Alternative, Alternative 1, and Alternative 2 may result in Level A harassment or mortality to species of large whales in the Study Area, including fin whale, blue whale, humpback whale, Bryde's whale, Omura's whale, sei whale, minke whale, and sperm whale. Impact from the use of vessels from training and testing activities is not expected to result in Level B harassment of marine mammals.

Pursuant to the ESA, the use of vessels during training and testing activities as described in the No Action Alternative, Alternative 1, and Alternative 2:

- *May affect, and is likely to adversely affect the ESA-listed fin whale, blue whale, humpback whale, sei whale, and sperm whale*

3.4.4.4.2 Impacts from In-Water Device Strikes

In-water devices are generally smaller (several inches to 111 ft. [34 m]) than most Navy vessels. For a discussion of the types of activities that use in-water devices, where they are used and how many events would occur under each alternative, see Section 3.0.5.2.3.3 (In-Water Devices).

Devices that would pose the greatest collision risk to marine mammals are those operated at high speeds and are unmanned. These are mainly limited to the unmanned surface vehicles such as high-speed targets and unmanned undersea vehicles such as light and heavy weight torpedoes. The Navy reviewed torpedo design features and a large number of previous anti-submarine warfare torpedo exercises to assess the potential of torpedo strikes on marine mammals. The acoustic homing programs of U.S. Navy torpedoes are sophisticated and would not confuse the acoustic signature of a marine mammal with a submarine/target. All exercise torpedoes are recovered and refurbished for eventual re-use. Review of the exercise torpedo records indicates there has never been an impact to a marine mammal or other marine organism.

Since some in-water devices are identical to support craft, marine mammals could respond to the physical presence of the device as discussed in Section 3.4.4.4.1 (Impacts from Vessels). Physical disturbance from the use of in-water devices is not expected to result in more than a momentary behavioral response.

Devices such as unmanned underwater vehicles that move slowly through the water are highly unlikely to strike marine mammals because the mammal could easily avoid the object. Towed devices are unlikely to strike a marine mammal because of the observers on the towing platform and other standard safety measures employed when towing in-water devices.

In thousands of exercises in which torpedoes were fired or in-water devices used, there have been no recorded or reported instances of a marine species strike from a torpedo or any other in-water device. Strikes by torpedoes or other in-water devices on individual marine mammals are not anticipated, and no long-term consequences to populations of marine mammals are expected to result from the use of in-water devices.

3.4.4.4.2.1 No Action Alternative, Alternative 1 and Alternative 2

Training Activities

In-water devices used for training activities in the Study Area are described in Section 3.0.5.2.3.3 (In-Water Devices). Under the No Action Alternative, approximately 174 training activities per year may use some type of in-water device. Under Alternative 1 and Alternative 2, the number of proposed annual training activities would increase by approximately 600 percent over the No Action Alternative. Torpedoes, unmanned underwater vehicles, unmanned targets, and other in-water devices could be used throughout the year and in multiple locations in the Study Area; however, nearly half of the activities using in-water devices would occur beyond 12 nm from shore. As described above, no impacts to marine mammals are anticipated from the use of in-water devices during training activities.

Pursuant to the MMPA, the use of in-water devices during training activities under the No Action Alternative, Alternative 1, or Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of in-water devices during training activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

In-water devices used for testing activities in the Study Area are described in Section 3.0.5.2.3.3 (In-Water Devices). Under the No Action Alternative, one testing activity per year may use some type of in-water device. Under Alternative 1 and Alternative 2, the number of proposed annual testing activities would increase to 320 under Alternative 1 and 362 under Alternative 2. Torpedoes, unmanned underwater vehicles, and other in-water devices could be used throughout the year and in multiple locations in the Study Area. As described above, no impacts to marine mammals are anticipated from the use of in-water devices during testing activities.

Pursuant to the MMPA, the use of in-water devices during testing activities under the No Action Alternative, Alternative 1, or Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of in-water devices during testing activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.4.3 Impacts from Military Expended Materials

This section analyzes the strike potential to marine mammals from the following categories of military expended materials: (1) non-explosive practice munitions; (2) fragments from high-explosive munitions; and (3) expended materials other than ordnance, such as sonobuoys, ship hulks, expendable targets and aircraft stores (fuel tanks, carriages, dispensers, racks, carriages, or similar types of support systems on aircraft that could be expended or recovered). For a discussion of the types of activities that use military expended materials, where they are used, and how many events would occur under each alternative, see Section 3.0.5.2.3 (Physical Disturbance and Strike Stressors).

While disturbance or strike from an item falling through the water column is possible, it is not very likely because the objects generally sink slowly through the water and can be avoided by most marine mammals. Therefore, the discussion of military expended materials strikes will focus on the potential of a strike at the surface of the water. For expended materials other than ordnance, potential strike is limited to expendable torpedo targets, sonobuoys, pyrotechnic buoys and aircraft stores.

While no strike from military expended materials has ever been reported or recorded, the possibility of a strike still exists. Therefore, the potential for marine mammals to be struck by military expended materials was evaluated using statistical probability analysis to estimate the likelihood. Specific details of the analysis approach, including the calculation methods, are presented in Appendix G (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures).

To estimate the likelihood of a strike, a worst-case scenario was calculated using the marine mammal with the highest average density in areas with the highest military expended material expenditures. These highest estimates would provide reasonable comparisons for all other areas and species. For estimates of expended materials in all areas, see Section 3.0.5.2.3 (Physical Disturbance and Strike Stressors).

For all the remaining marine mammals with lesser densities, this highest likelihood would overestimate the likelihood or probability of a strike. Because the ESA has a specific standards for understanding the likelihood of impacts to each endangered species, estimates were made for all endangered marine mammals found in the areas where the highest levels of military expended materials would be expended. In this way, the appropriate ESA conclusions could be based on the highest estimated probabilities of a strike for those species.

Input values include munitions data (frequency, footprint and type), size of the training or testing area, marine mammal density data and size of the animal. To estimate the potential of military expended materials to strike a marine mammal, the impact area of all bomb, projectiles, acoustic countermeasures, expendable torpedo targets, sonobuoys and pyrotechnic buoys was totaled over 1 year in the area for each of the alternatives.

The potential for a marine mammal strike is influenced by the following assumptions:

- The statistical analysis is two-dimensional and assumes that all marine mammals would be at or near the surface 100 percent of the time, when in fact, marine mammals spend up to 90 percent of their time under the water (Costa and Block 2009).
- The statistical analysis also does not take into account the fact that most of the projectiles fired during training and testing activities are fired at targets, and most projectiles hit those targets, so only a very small portion of those would hit the water with their maximum velocity and force.
- The statistical analysis assumes the animal is stationary and does not account for any movement of the marine mammal or any potential avoidance of the training or testing activity.

The potential of fragments from explosive munitions or expended material other than ordnance to strike a marine mammal is likely lower than for the worst-case scenario calculated above as those events happen with much lower frequency. Fragments may include metallic fragments from the exploded target, as well as from the exploded ordnance.

Marine mammal species that occur in the Study Area may be exposed to the risk of military expended material strike. The critical habitat would not be impacted by military expended materials as a physical disturbance and strike stressor. The results of the statistical analysis provide a reasonably high level of certainty that marine mammals would not be struck by military expended materials. See Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), for a description of mitigation measures proposed to help further reduce the potential impacts of military expended materials strikes on marine mammals.

3.4.4.4.3.1 No Action Alternative, Alternative 1, and Alternative 2

Training and Testing Activities

As shown in Section 3.0.5.2.3.4 (Military Expended Materials), a wide variety of expended materials are used during training and testing activities. Military expended materials used in the Study Area include all sizes of non-explosive practice munitions, fragments from explosive munitions, and expended materials other than ordnance, such as sonobuoys.

Under Alternatives 1 and 2, the use of military expended materials from training activities increases by approximately 130 percent compared to the No Action Alternative. There are no testing activities under the No Action Alternative that use military expended materials, and the number of military expended materials used in testing activities under Alternatives 1 and 2 is approximately 10 percent of the total used in training activities.

The results of the statistical analysis provided in Appendix G (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures) present the probability of a strike from military expended materials as a percent of training or testing activities under the No Action Alternative, Alternative 1, and Alternative 2. The results indicate with a reasonable level of certainty that marine mammals would not be struck by non-explosive practice munitions or by military expended materials other than munitions during training or testing activities. The results of the analysis range from zero (i.e., or a zero percent chance of a strike by a military expended material over the course of a year), to a high of approximately eight one-hundredths of one percent (0.08 percent) of a chance of being struck by a military expended material. However, as discussed above, this does not take into account assumptions that likely overestimate impact probability and the behavior of the species (e.g., melon-headed whales generally occur in large pods and are relatively easy to spot), which would make the risk of a strike even lower.

The increase in expended materials from the No Action Alternative–Alternatives 1 and 2 results in a corresponding increase of the risk of a strike as shown in Appendix G (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures), but it does not change the underlying conclusion that the use of military expended materials is not expected to result in the physical disturbance or a strike of marine mammals. Furthermore, Navy mitigation measures addressing the use of sonobuoys and other military expended materials require that the area is clear of marine mammals before deploying sonobuoys or other types of military expended materials (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring).

Pursuant to the MMPA, the use of military expended materials during training or testing activities under the No Action Alternative, Alternative 1, or Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials during training or testing activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.4.4 Impacts from Seafloor Devices

For a discussion of the types of activities that use seafloor devices, where they are used, and how many events would occur under each alternative, see Section 3.0.5.2.3.5 (Seafloor Devices). These include items placed on, dropped on or moved along the seafloor, such as mine shapes, anchor blocks, anchors, bottom-placed instruments, and bottom-crawling unmanned underwater vehicles. As discussed in Section 3.4.4.4.3 (Impacts from Military Expended Materials), objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most marine mammals. The only seafloor device used during training and testing activities that has the potential to strike a marine mammal at or near the surface is an aircraft deployed mine shape, which is used during aerial mine laying activities. These devices are identical to non-explosive practice bombs, therefore the analysis of the potential impacts from those devices are covered in the military expended material strike section.

3.4.4.4.4.1 No Action Alternative, Alternative 1, and Alternative 2

<u>Training Activities</u>

As indicated in Section 3.0.5.2.3.5 (Seafloor Devices), some training activities, including mine warfare, precisions anchoring, and anti-submarine warfare activities under the No Action Alternative, Alternative 1, and Alternative 2 make use of seafloor devices. Under the No Action Alternative, 44 training activities per year would use seafloor devices. Under Alternative 1 and Alternative 2, 136 training activities would use seafloor devices.

Some seafloor devices are put into place prior to or during the training activity and recovered following the activity (e.g., anchors used in Precision Anchoring activities and moored mine shapes used in some mine warfare activities). Recovery of other types of seafloor devices (e.g., air-deployed, non-explosive mine shapes) would not be practical or even possible, because of factors inhibiting recovery, such as water depth. Considering that activities using seafloor devices would only be conducted 136 times per year and that many seafloor devices would be recovered, it is unlikely that marine mammals would come into contact with these devices while they are being deployed, recovered, or during the training activity.

Pursuant to the MMPA, the use of seafloor devices during training activities under the No Action Alternative, Alternative 1, or Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of seafloor devices during training activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *Would have no effect on the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As indicated in Section 3.0.5.2.3.5 (Seafloor Devices), one testing activity under the No Action Alternative would use seafloor devices. Under Alternatives 1 and 2, up to 68 testing activities would use seafloor devices.

Testing activities using seafloor devices include the North Pacific Acoustic Lab Philippine Sea Experiment conducted by the Office of Naval Research, which would occur once per year, the integrated swimmer defense airgun activity conducted 11 times per year, and Mine Countermeasure Mission Package Testing (up to 36 times per year) (see Chapter 2, Description of Proposed Action and Alternatives, Tables 2.8-3 and 2.8-4). Seafloor devices are put into place prior to or during the testing activity and recovered following the activity. Considering that activities using seafloor devices would only occur 68 times per year and that all devices used during swimmer defense airgun testing and moored mine shapes used in MCM Mission Package testing would be recovered, it is unlikely that marine mammals would come into contact with these devices while they are being deployed or during the testing activity.

Pursuant to the MMPA, the use of seafloor devices during testing activities under the No Action Alternative, Alternative 1, or Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of seafloor devices during testing activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *Would have no effect on the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.5 Entanglement Stressors

This section analyzes the potential for entanglement of marine mammals as the result of proposed training and testing activities within the Study Area. This analysis includes the potential impacts from two types of military expended materials: (1) fiber optic cables and guidance wires and (2) decelerators/

parachutes. The number and location of training and testing events that involve the use of items that may pose an entanglement risk are provided in Section 3.0.5.2.4 (Entanglement Stressors).

These materials may have the potential to entangle and could be encountered by marine mammals in the Study Area at the surface, in the water column, or along the seafloor. The properties and size of these military expended materials makes entanglement unlikely. For example, the majority of the "parachutes" expended are 18 in. (45.7 cm) diameter cruciform ("X" shaped) decelerators attached with short lines to the top of sonobuoys and are therefore very unlikely entanglement hazards for most marine mammals. In addition, there has never been a reported or recorded instance of a marine mammal entangled in military expended materials; however, the possibility still exists. Since potential impacts depend on how a marine mammal encounters and reacts to items that pose an entanglement risk, the following subsections discuss research relevant to specific groups or species. Most entanglements discussed in the following sections are attributable to marine mammal encounters with fishing gear or other non-military materials that float or are suspended at the surface.

3.4.4.5.1 Mysticetes

The minimal estimate of the percentage of humpback whales that have been non-lethally entangled in their lifetime is 52 percent with a maximal estimate of 78 percent (Neilson et al. 2009). Cassoff et al. (2011) report that in the western North Atlantic, mortality entanglement has slowed the recovery of some populations of mysticetes. Included in their analysis of 21 entanglement related mortalities were minke, Bryde's, North Atlantic right whale, and humpback whales.

There are no data available for the MITT Study Area. However, in the Hawaiian Islands in 2006 and 2007, there were 26 entanglements in each of those 2 years (National Marine Fisheries Service 2007). In 2008 there were 15 entanglements (National Marine Fisheries Service 2008b), and in the Hawaiian Islands during the 2009–2010 humpback season, the Hawaiian Islands Large Whale Entanglement Response Network received 32 reports of entangled humpback whales, with 19 of these reports were confirmed and amounted to 11 different animals entangled in various types of gear (National Marine Fisheries Service 2010).

Military expended material is expected to sink to the ocean floor. There are no mysticete species that feed off the bottom in the areas where activities make use of military expended materials could encounter them.

3.4.4.5.2 Odontocetes

Heezen (1957) reported two confirmed instances of sperm whales entangled in the slack lengths of telegraph cable near cable repair sites along the seafloor. These whales likely became entangled while feeding along the bottom, as the cables were most often found wrapped around the jaw. Juvenile harbor porpoise exposed to 0.5 in. diameter (13-millimeter [mm] diameter) white nylon ropes in both vertical and horizontal planes treated the ropes as barriers, more frequently swimming under than over them (Kastelein et al. 2005). Bottlenose dolphins have also been observed to feed off the bottom in shallow water in the Bahamas (Herzing et al. 2003).

Walker and Coe (1990) provided data on the stomach contents from 16 species of odontocetes with evidence of debris ingestion. Of the odontocete species occurring in the Study Area, only sperm whale, Blainville's beaked whale, and Cuvier's beaked whale had ingested items (likely incidentally) that do not float, indicating the likelihood of foraging at the seafloor.

3.4.4.5.3 Impacts from Fiber Optic Cables and Guidance Wires

For a discussion of the types of activities that use fiber optic cables and guidance wires and how many events would occur under each alternative, see Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires). The likelihood of a marine mammal encountering and becoming entangled in a fiber optic cable depends on several factors. The amount of time that the cable is in the same vicinity as a marine mammal can increase the likelihood of it posing an entanglement risk. Since the cable will only be within the water column during the activity and while it sinks, the likelihood of a marine mammal encountering and becoming entangled within the water column is extremely low. The length of the fiber optic cable varies (up to about 900 ft. [274 m]), and greater lengths may increase the likelihood that a marine mammal could become entangled. The behavior and feeding strategy of a species can determine whether they may encounter items on the seafloor, where cables will be available for longer periods of time. There is potential for those species that feed on the seafloor to encounter cables and potentially become entangled, however the relatively few cables being expended within the Study Area limits the potential for encounters. The physical characteristics of the fiber optic material render the cable brittle and easily broken when kinked, twisted, or bent sharply (i.e., to a radius greater than 360 degrees). Thus, the physical properties of the fiber optic cable would not allow the cable to loop, greatly reducing or eliminating any potential issues of entanglement with regard to marine life.

Similar to fiber optic cables discussed above, guidance wires may pose an entanglement threat to marine mammals either in the water column or after the wire has settled to the sea floor. The likelihood of a marine mammal encountering and becoming entangled in a guidance wire depends on several factors. With the exception of a chance encounter with the guidance wire while it is sinking to the seafloor (at an estimated rate of 0.7 ft. [0.2 m] per second), it is most likely that a marine mammal would only encounter a guidance wire once it had settled on the sea floor. Since the guidance wire will only be within the water column during the activity and while it sinks, the likelihood of a marine mammal encountering and becoming entangled within the water column is extremely low. In addition, based on degradation times the guide wires would break down within 1–2 years and therefore no longer pose an entanglement risk. The length of the guidance wires vary, but greater lengths increase the likelihood that a marine mammal could become entangled. The behavior and feeding strategy of a species can determine whether they may encounter items on the seafloor, where guidance wires will most likely be available. There is potential for those species that feed on the seafloor to encounter guidance wires and potentially become entangled; however, the relatively few guidance wires being expended within the Study Area limits the potential for encounters.

Marine mammal species that occur within the Study Area were evaluated based on the likelihood of encountering these items. There are no mysticete species in the Study Area that feed off the bottom in the areas where these activities occur. Odontocete species, that occur in these areas and that forage on the bottom, (e.g., beaked whales) could potentially encounter these items.

The chance that an individual animal would encounter expended cables or wires is low based on the distribution of both the cables and wires expended, the fact that the wires and cables will sink upon release, and the relatively few marine mammals that are likely to feed on the bottom in the deeper waters (e.g., average depth in Warning Area [W]-517 is 19,600 ft. [6,000 m]) where these would be expended. It is probably very unlikely that an animal would get entangled even if it encountered a cable or wire while it was sinking or upon settling to the seafloor. An animal would have to swim through loops or become twisted within the cable or wire to become entangled and, given the properties of the expended fiber optic cables and guidance wires (low breaking strength and sinking rates), this seems unlikely. Furthermore, an animal may initially become entangled in a cable or wire but easily become free, and therefore no long-term impacts would occur. Based on the estimated concentration of expended cables and wires, impacts from cables or wires are extremely unlikely to occur.

3.4.4.5.3.1 No Action Alternative

Training Activities

As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), training activities under the No Action Alternative would expend approximately 40 guidance wires annually, and no activities would expend fiber optic cables. Based on the discussion above, impacts on marine mammals from the use of guidance wires during training activities under the No Action Alternative are not anticipated. Long-term consequences to individuals or populations of marine mammals are not expected to result from the use of guidance wires.

Pursuant to the MMPA, the use of guidance wires during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of guidance wires during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), no testing activities under the No Action Alternative would expend fiber optic cables or guidance wires.

3.4.4.5.3.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), 4 training activities would use approximately 16 fiber optic cables and 40 training activities would use 40 guidance wires annually under Alternative 1.

The number of events using guidance wires is the same as under the No Action Alternative. The number of fiber optic cables that would be expended annually increased from zero under the No Action Alternative to 16 under Alternative 1. Based on the discussion above, and the minimal increase in the use of fiber optic cables, impacts on marine mammals from the use of guidance wires and fiber optic cables during training activities under Alternative 1 are not anticipated and would not be discernible from impacts described under Section 3.4.4.5.3 (Impacts from Fiber Optic Cables and Guidance Wires).

Pursuant to the MMPA, the use of fiber optic cables and guidance wires during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), two testing activities under Alternative 1 would expend 20 guidance wires, and 32 testing activities under Alternative 1 would expend 128 fiber optic cables annually. Based on the discussion above, impacts on marine mammals from the use of fiber optic cables and guidance wires during testing activities under Alternative 1 are not anticipated and would not be discernible from impacts described under Section 3.4.4.5.3 (Impacts from Fiber Optic Cables and Guidance Wires).

Pursuant to the MMPA, the use of fiber optic cables and guidance wires during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.5.3.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus modifications of existing capabilities and adjustments to the type and tempo of training and testing activities. As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), the number of expended guidance wires and fiber optic cables under Alternative 2 is identical to Alternative 1. Therefore, the predicted impacts for Alternative 2 are identical to those described above under Alternative 1 – Training. Based on the discussion above, impacts on marine mammals from the use of fiber optic cables and guidance wires during training activities under Alternative 2 are not anticipated and would not be discernible from impacts described under Section 3.4.4.5.3 (Impacts from Fiber Optic Cables and Guidance Wires).

Pursuant to the MMPA, the use of fiber optic cables and guidance wires during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), the number of expended guidance wires under Alternative 2 is identical to Alternative 1. The number of fiber optic cables used under Alternative 2 increases to 144 per year (less than a 13 percent increase). Therefore, the predicted impacts for Alternative 2 are approximately the same as those described above under Alternative 1 – Testing. Based on the discussion above, impacts on marine mammals from the use of fiber optic cables and guidance wires during testing activities under Alternative 2 are not anticipated and would not be discernible from impacts described under Section 3.4.4.5.3 (Impacts from Fiber Optic Cables and Guidance Wires).

Pursuant to the MMPA, the use of fiber optic cables and guidance wires during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.5.4 Impacts from Decelerators/Parachutes

Refer to Section 3.0.5.2.4.2 (Decelerators/Parachutes), for information on the types of training and testing activities that involve the use of decelerators/parachutes and the geographic areas where they would be expended. Training and testing activities that introduce decelerators/parachutes into the water column can occur anywhere in the Study Area.

As described in Section 3.0.5.2.4.2 (Decelerators/Parachutes), decelerators/parachutes used during the proposed activities are small, ranging in size from 18 to 48 in. (46 to 122 cm), and are made of cloth and nylon. Many decelerators/parachutes have weights attached to the lines for rapid sinking. The vast majority of expended decelerators/parachutes are small (18 in. [45.7 cm]) cruciform-shaped decelerators used with sonobuoys. These have short attachment lines and upon water impact may remain at the surface for 5–15 seconds before the decelerator/parachute and its housing sink to the seafloor. The average water depth in W-517 is approximately 19,600 ft. (6,000 m).

Entanglement of a marine mammal in a decelerator/parachute assembly at the surface or within the water column would be very unlikely, since the decelerator/parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. Once on the seafloor, if strong enough bottom currents are present, the small fabric panels may temporarily billow and pose an entanglement threat to marine animals with bottom-feeding habits; however, the probability of a marine mammal encountering a decelerator/parachute assembly on the seafloor and accidental entanglement in the small, cruciform fabric panel or short suspension lines is unlikely.

The chance that an individual animal would encounter expended decelerators/parachutes is low based on the distribution of the decelerators/parachutes expended, the fact that decelerator/parachute assemblies are designed to sink upon release, and the relatively few marine mammals that feed on the bottom. If a marine mammal did become entangled in a parachute, it could easily become free of the parachute because the parachutes are made of very light-weight fabric. Based on the information summarized within the introduction to Section 3.4.4.5 (Entanglement Stressors), mysticetes found within the Study Area are not bottom feeders; therefore, they are not expected to encounter decelerators/parachutes on the seafloor.

The possibility of odontocetes (sperm whale, Blainville's beaked whale, Cuvier's beaked whale) becoming entangled exists when they are feeding on the bottom in areas where decelerators/parachutes have been expended. This is unlikely as decelerators/parachutes are used in events that generally occur in deeper waters where these species are not likely to be feeding on the bottom (Whitehead 2003) and the majority of decelerators/parachutes used are relatively small. There has never been any recorded or reported instance of a marine mammal becoming entangled in a decelerator/parachute.

3.4.4.5.4.1 No Action Alternative

Training Activities

As presented in Section 3.0.5.2.4.2 (Decelerators/Parachutes), approximately 8,000 decelerators/parachutes would be expended annually during training activities.

A calculation was made to estimate the highest possible concentration of expended decelerators/parachutes that could be expected in the Study Area. The result is a concentration of approximately one decelerator/parachute per 7 square nautical miles (nm^2) of ocean area. Based on the description of decelerators/parachutes in Section 3.4.4.5.4 (Impacts from Decelerators/Parachutes) and the estimated low density of decelerators/parachutes, impacts on marine mammals from the use of decelerators/parachutes during training activities under the No Action Alternative are not anticipated.

Pursuant to the MMPA, the use of decelerators/parachutes during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As presented in Section 3.0.5.2.4.2 (Decelerators/Parachutes), there are no testing activities under the No Action Alternative that would expend decelerators/parachutes.

3.4.4.5.4.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As presented in Section 3.0.5.2.4.2 (Decelerators/Parachutes, Tables 3.0-33 and 3.0-49), approximately 11,000 decelerators/parachutes would be expended annually during training activities under Alternative 1. This represents a 35 percent increase in the number of expended decelerators/parachutes over the No Action Alternative.

A calculation was made to estimate the highest possible concentration of expended decelerators/parachutes that could be expected in a worst-case scenario. The result is a concentration of approximately one decelerator/parachute per 4 nm^2 of ocean area within the Study Area. Based on the description of decelerators/parachutes in Section 3.4.4.5.4 (Impacts from Decelerators/Parachutes) and the estimated low density of decelerators/parachutes, impacts on marine mammals from the use of decelerators/parachutes during training activities under Alternative 1 are not anticipated.

Pursuant to the MMPA, the use of decelerators/parachutes during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As presented in Section 3.0.5.2.4.2 (Decelerators/Parachutes), approximately 1,700 decelerators/parachutes would be expended annually during testing activities under Alternative 1.

A calculation was made to estimate the highest possible concentration of expended decelerators/ parachutes that could be expected in a worst-case scenario. The result is a concentration of approximately one decelerator/parachute per 14 nm^2 of ocean area within the Study Area. Based on the description of decelerators/parachutes in Section 3.4.4.5.4 (Impacts from Decelerators/Parachutes) and the estimated low density of decelerators/parachutes, impacts on marine mammals from the use of decelerators/parachutes during testing activities under Alternative 1 are not anticipated.

Pursuant to the MMPA, the use of decelerators/parachutes during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.5.4.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. Decelerators/Parachutes could be expended anywhere in the Study Area during training activities. As shown in Section 3.0.5.2.4.2 (Decelerators/Parachutes), the number of decelerators/parachutes used during training activities is identical under Alternatives 1 and 2. Therefore, the predicted impacts for Alternative 2 are identical to those described under Alternative 1 – Training.

Pursuant to the MMPA, the use of decelerators/parachutes during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. As presented in Section 3.0.5.2.4.2 (Decelerators/Parachutes), approximately 1,900 decelerators/parachutes would be expended annually during testing activities under Alternative 2. This represents a 10 percent increase in the number of expended decelerators/parachutes over the Alternative 1.

A calculation was made to estimate the highest possible concentration of expended decelerators/ parachutes that could be expected in a worst-case scenario. The result is a concentration of approximately one decelerator/parachute per 13 nm^2 of ocean area within the Study Area. Based on the description of decelerators/parachutes in Section 3.4.4.5.4 (Impacts from Decelerators/Parachutes) and the estimated low density of decelerators/parachutes, impacts on marine mammals from the use of decelerators/parachutes during testing activities under Alternative 2 are not anticipated.

Pursuant to the MMPA, the use of decelerators/parachutes during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.6 Ingestion Stressors

This section analyzes the potential impacts of the various types of ingestion stressors used during training and testing activities within the Study Area. This analysis includes the potential impacts from two categories of military expended materials: (1) munitions (both non-explosive practice munitions and fragments from explosive munitions); and (2) materials other than ordnance including fragments from targets, chaff, flares, and decelerators/parachutes. For a discussion of the types of activities that use these materials, where they are used, and how many events would occur under each alternative, please see Section 3.0.5.2.5 (Ingestion Stressors).

The distribution and density of expended items plays a central role in the likelihood of impact on marine mammals. The military conducts training and testing activities throughout the Study Area and these activities are widely distributed and low in density. As suggested by the seafloor survey reported in Watters et al. (2010), even in areas such as Southern California (within the Navy's SOCAL Range Complex) where Navy has been undertaking training and testing activities for decades, the density of materials expended by Navy is negligible in comparison to commercial fishing and urban refuse resulting in marine debris available on seafloor. Watters et al. (2010) found an estimated 320 anthropogenic items per square kilometer on Southern California seafloor and encountered only one item (identified as "artillery") that was of likely military origin. The majority of material expended during military training and testing would likely penetrate into the seafloor and not be accessible to most marine mammals.

Since potential impacts depend on where these items are expended and how a marine mammal feeds, the following subsections discuss important information for specific groups or species.

3.4.4.6.1 Mysticetes

Species that feed at the surface or in the water column include blue, fin, Bryde's, Omura's, minke, and sei whales. While humpback whales feed predominantly by lunging through the water after krill and fish, there are instances of humpback whales disturbing the bottom in an attempt to flush prey, the northern sand lance (*Ammodytes dubius*) (Hain et al. 1995). Humpback whales are not known to bottom feed while in the Study Area. In a comprehensive review of documented ingestion of debris by marine mammals, there are two species of mysticetes (bowhead and minke whale) with records of having ingested debris items that included plastic sheeting and a polythene bag (Laist 1997). Based on the available evidence, and because minke whales and humpback whales occur in the Study Area and are known to forage at or near the seafloor, it is possible but unlikely they may ingest items found on the seafloor.

3.4.4.6.2 Odontocetes

Beaked whales use suction feeding to ingest benthic prey and may incidentally ingest other items (MacLeod et al. 2003). Both sperm whales and beaked whales are known to incidentally ingest foreign objects while foraging; however, this does not always result in negative consequences to health or vitality (Laist 1997; Walker and Coe 1990). While this incidental ingestion has led to sperm whale mortality in some cases (Jacobsen et al. 2010), Whitehead (2003) suggested the scale to which this affects sperm whale populations was not substantial. Sperm whales are recorded as having ingested fishing net scraps, rope, wood, and plastic debris such as plastic bags and items from the seafloor (Walker and Coe 1990; Whitehead 2003). In addition, the results presented in Whitehead (2003) suggest that ingestion of non-food items is more likely at higher latitudes than at lower latitudes.

Recently weaned juveniles, who are investigating multiple types of prey items, may be particularly vulnerable to ingesting non-food items as found in a study of juvenile harbor porpoise (Baird and Hooker 2000). A male pygmy sperm whale reportedly died from blockage of two stomach compartments by hard plastic, and a Blainville's beaked whale washed ashore in Brazil with a ball of plastic thread in its stomach (Derraik 2002). In a comprehensive review of documented ingestion of debris by marine mammals, odontocetes had the most ingestion records with 21 species represented (Laist 1997). Walker and Coe (1990) provided data on the stomach contents from of 16 species of odontocetes with evidence of debris ingestion. Of these odontocete species, only sperm whale, Blainville's beaked whale, Cuvier's beaked whale had ingested non-floating items (e.g., stones, metal, and glass) presumably while foraging from the seafloor. Bottlenose dolphins have also been observed to feed off the bottom in shallow water in the Bahamas (Herzing et al. 2003). Table 3.4-25 lists odontocete species found in the Study Area that are known to have ingested marine debris.

Table 3.4-25: Odontocete Marine Mammal Species that Occur in the Study Area and Are Documented to Have Ingested Marine Debris

Blainville's beaked whale	Risso's dolphin
Bottlenose dolphin	Rough-toothed dolphin
Cuvier's beaked whale	Short-finned pilot whale
Dwarf sperm whale	Sperm whale
Pygmy sperm whale	Striped dolphin

Source: Walker and Coe 1990

3.4.4.6.3 Impacts from Munitions

Many different types of explosive and non-explosive practice munitions are expended during training and testing activities. This section analyzes the potential for marine mammals to ingest non-explosive practice munitions and fragments from explosive munitions.

Types of non-explosive practice munitions generally include projectiles, missiles, and bombs. Of these, only small- or medium-caliber projectiles would be small enough for a marine mammal to ingest. Small- and medium-caliber projectiles include all sizes up to and including 2.25 in. (57 mm) in diameter. These solid metal materials would quickly move through the water column and settle to the sea floor. Ingestion of non-explosive practice munitions is not expected to occur in the water column because the ordnance sinks quickly. Instead, they are most likely to be encountered by species that forage on the bottom. Other military expended materials such as targets, large-caliber projectiles, intact training and testing bombs, guidance wires, 55-gallon drums, sonobuoy tubes, and marine markers are too large for marine mammals to consume.

Types of explosive munitions that can result in fragments include demolition charges, neutralizers, projectiles, missiles, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the size of the NEW and munitions type; however, typical sizes of fragments are unknown. These solid metal materials would quickly move through the water column and settle to the seafloor; therefore, ingestion is not expected by most species. Fragments are primarily encountered by species that forage on the bottom.

Based on the information summarized above in 3.4.4.6 (Ingestion Stressors), mysticetes found within the Study Area, with the potential exception of humpback whale and minke whale, are not expected to encounter non-explosive practice munitions or fragments from explosive munitions on the seafloor. Ingestion of non-explosive practice munitions or fragments from explosive munitions by odontocetes feeding off the bottom is unlikely. If ingestion were to occur, it would d be incidental with items being potentially consumed along with bottom-dwelling prey.

3.4.4.6.3.1 No Action Alternative

Training Activities

Explosive munitions and non-explosive practice munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under the No Action Alternative, more than 61,700 explosive munitions and non-explosive practice munitions considered an ingestion risk would be used during training activities annually in the Study Area. Of that total, 60,000 are non-explosive, small-caliber projectiles, and the remaining are explosive munitions, including bombs, medium- and large-caliber projectiles, missiles, and rockets, that could introduce fragments potentially small enough to be ingested by a bottom feeding marine mammal. All explosive bombs, missiles, and large-caliber projectiles would be used over deep, offshore waters greater than 12 nm (and in some cases greater than 50 nm) from shore. Over 60 percent of non-explosive, small-caliber projectiles would be expended greater than 12 nm from shore.

The number of munitions and explosive munitions fragments that an individual animal could encounter would generally be low, based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not ingest every munitions or munitions fragment it encountered, and if a munition or munitions fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. Wells et al. (2008) showed that even ingestion of certain items (e.g., hooks), if they do not become embedded in tissue, may not result in injury or mortality to the individual. Therefore, potential impacts of munitions ingestion would be limited to the unlikely event where a marine mammal might ingest an item that subsequently becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, ingestion of munitions used during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, ingestion of munitions used during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

Explosive munitions and non-explosive practice munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), there are no testing activities proposed under the No Action Alternative that would use explosive munitions or non-explosive practice munitions in the Study Area.

3.4.4.6.3.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

Explosive munitions and non-explosive practice munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 1, approximately 97,000 explosive munitions and non-explosive practice munitions considered an ingestion risk would be used during training activities annually in the Study Area. Of that total, 86,000 are non-explosive, small-caliber projectiles, and the remaining are explosive munitions, including bombs, medium- and large-caliber projectiles, missiles, and rockets, that could introduce fragments potentially small enough to be ingested by a bottom feeding marine mammal. The number of explosive munitions and non-explosive practice munitions proposed under Alternative 1 represents an increase of 57 percent over the number proposed under the No Action Alternative. All explosive bombs, missiles, rockets, and large-caliber projectiles would be used over deep, offshore waters greater than 12 nm (and in some cases greater than 50 nm) from shore. Approximately 45 percent of non-explosive, small-caliber projectiles would be expended greater than 12 nm from shore, and 98 percent of explosive medium-caliber projectiles would be expended greater than 12 nm from shore.

The number of munitions and explosive munitions fragments that an individual animal could encounter would generally be low, based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not ingest every munitions or munitions fragment it encountered, and if a munition or munitions fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. Wells et al. (2008) showed that even ingestion of certain items (e.g., hooks), if they do not become embedded in tissue, may not result in injury or mortality to the individual. Therefore, potential impacts of munitions ingestion would be limited to the unlikely event where a marine mammal might ingest an item that subsequently becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, ingestion of munitions used during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, ingestion of munitions used during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

Explosive munitions and non-explosive practice munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 1, approximately 11,000 explosive munitions and non-explosive practice munitions considered an ingestion risk would be used during testing activities annually in the Study Area. Of that total, approximately 4,000 are non-explosive, small-caliber or medium-caliber projectiles, and the remaining 7,000 are explosive munitions. Eighty-seven percent of the explosive munitions are medium- and large-caliber projectiles, and the remaining 13 percent are missiles, rockets, and torpedoes.

Explosive munitions could introduce fragments potentially small enough to be ingested by a bottom feeding marine mammal. The number of explosive munitions and non-explosive practice munitions proposed under Alternative 1 is an increase over the number proposed under the No Action alternative, because no testing activities would use munitions under the No Action Alternative.

The number of munitions and explosive munitions fragments that an individual animal could encounter would generally be low, based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not ingest every munitions or munitions fragment it encountered, and if a munition or munitions fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. Wells et al. (2008) showed that even ingestion of certain items (e.g., hooks), if they do not become embedded in tissue, may not result in injury or mortality to the individual. Therefore, potential impacts of munitions ingestion would be limited to the unlikely event where a marine mammal might ingest an item that subsequently becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, ingestion of munitions used during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, ingestion of munitions used during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.6.3.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities.

Explosive munitions and non-explosive practice munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 2, approximately 97,000 explosive munitions and non-explosive practice munitions considered an ingestion risk would be used during training activities annually in the Study Area. Of that total, 86,000 are non-explosive, small-caliber projectiles, and the remaining are explosive munitions, including bombs, medium- and large-caliber projectiles, missiles, and rockets, that could introduce fragments potentially small enough to be ingested by a bottom feeding marine mammal. The number of explosive munitions and non-explosive practice munitions proposed under Alternative 2 represents an increase of 57 percent over the number proposed under the No Action Alternative and is approximately equivalent to Alternative 1. All explosive bombs, missiles, rockets, and large-caliber projectiles would be used over deep, offshore waters greater than 12 nm (and in some cases greater than 50 nm) from shore. Approximately 45 percent of non-explosive, small-caliber projectiles would be expended greater than 12 nm from shore, and 98 percent of explosive medium-caliber projectiles would be expended greater than 12 nm from shore.

The number of munitions and explosive munitions fragments that an individual animal could encounter would generally be low, based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not ingest every munitions or munitions fragment it encountered, and if a munition or munitions fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. Wells et al. (2008) showed that even ingestion of certain items (e.g., hooks), if they do not become embedded in tissue, may not result in injury or mortality to the individual. Therefore, potential impacts of munitions ingestion would be limited to the unlikely event where a marine mammal might ingest an item that subsequently becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, ingestion of munitions used during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, ingestion of munitions used during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

Explosive munitions and non-explosive practice munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 2, approximately 13,000 explosive munitions and non-explosive practice munitions considered an ingestion risk would be used during testing activities annually in the Study Area. Of that total, approximately 5,000 are non-explosive small-caliber or medium-caliber projectiles, and the remaining 8,000 are explosive munitions. Eighty-eight percent of the explosive munitions are medium- and large-caliber projectiles, and the remaining 12 percent are missiles, rockets, and torpedoes.

Explosive munitions could introduce fragments potentially small enough to be ingested by a bottom-feeding marine mammal. The number of explosive munitions and non-explosive practice munitions proposed under Alternative 2 is an increase over the number proposed under the No Action Alternative, because no testing activities would use munitions under the No Action Alternative. The number of explosive munitions and non-explosive practice munitions proposed under Alternative 2 is an increase approximately 25 percent over the number proposed under Alternative 1.

The number of munitions and explosive munitions fragments that an individual animal could encounter would generally be low, based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not ingest every munitions or munitions fragment it encountered, and if a munition or munitions fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. Wells et al. (2008) showed that even ingestion of certain items (e.g., hooks), if they do not become embedded in tissue, may not result in injury or mortality to the individual. Therefore, potential impacts of munitions ingestion would be limited to the unlikely event where a marine mammal might ingest an item that subsequently becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, ingestion of munitions used during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, ingestion of munitions used during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.6.4 Impacts from Military Expended Materials Other than Munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), several different types of materials other than munitions are expended at sea during training and testing activities. The following military expended materials other than munitions have the potential to be ingested by bottom feeding marine mammals:

- Target-related materials
- Chaff (including fibers, end caps, and pistons)
- Flares (including end caps and pistons)
- Decelerators/Parachutes (cloth, nylon, and metal weights)

Target-Related Materials

At-sea targets are usually remotely operated airborne, surface, or subsurface traveling units, many of which are designed to be recovered for reuse. If they are severely damaged or displaced, targets may sink before they can be retrieved. Expendable targets include air-launched decoys, marine markers (smoke floats), cardboard boxes, and 10 ft. (3 m) diameter red balloons tethered by a sea anchor. Most target fragments would sink quickly in the sea. Floating material, such as Styrofoam, may be lost from target boats and remain at the surface for some time.

Chaff

Chaff is an electronic countermeasure designed to reflect radar waves and obscure aircraft, vessels, and other equipment from radar tracking sources. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide (U.S. Air Force 1997). Chaff is released or dispensed in cartridges or projectiles that contain millions of chaff fibers. When deployed, a diffuse cloud of fibers undetectable to the human eye is formed. Chaff is a very light material that can remain suspended in air anywhere from 10 minutes to 10 hours and can travel considerable distances from its release point, depending on prevailing atmospheric conditions (U.S. Air Force 1997; Arfsten et al. 2002). Doppler radar has tracked chaff plumes containing approximately 900 grams of chaff drifting 200 mi. (322 km) from the point of release, with the plume covering greater than 400 $mi.^3$ (1,700 km^3) (Arfsten et al. 2002).

The chaff concentrations that marine mammals could be exposed to following release of multiple cartridges (e.g., following a single day of training) is difficult to accurately estimate because it depends on several unknown factors. First, specific release points are not recorded and tend to be random, and chaff dispersion in air depends on prevailing atmospheric conditions. After falling from the air, chaff fibers would be expected to float on the sea surface for some period, depending on wave and wind action. The fibers would be dispersed further by sea currents as they float and slowly sink toward the bottom. Chaff concentrations in benthic habitats following release of a single cartridge would be lower than the values noted in this section, based on dispersion by currents and the enormous dilution capacity of the receiving waters.

Several literature reviews and controlled experiments have indicated that chaff poses little risk, except at concentrations substantially higher than those that could reasonably occur from military training (U.S. Air Force 1997; Hullar et al. 1999; Arfsten et al. 2002). Nonetheless, some marine mammal species within the Study Area could be exposed to chaff through direct body contact and ingestion. Chemical alteration of water and sediment from decomposing chaff fibers is not expected to result in exposure. Based on the dispersion characteristics of chaff, it is likely that marine mammals would occasionally come in direct contact with chaff fibers while at the water's surface and while submerged, but such contact would be inconsequential. Chaff is similar to fine human hair (U.S. Air Force 1997). Because of the flexibility and softness of chaff, external contact would not be expected to impact most wildlife (U.S. Air Force 1997), and the fibers would quickly wash off shortly after contact. Given the properties of chaff, skin irritation is not expected to be a problem (U.S. Air Force 1997). Arfsten et al. (2002), Hullar et al. (1999), and U.S. Air Force (1997) reviewed the potential effects of chaff inhalation on humans, livestock, and animals and concluded that the fibers are too large to be inhaled into the lung. The fibers are predicted to be deposited in the nose, mouth, or trachea and are either swallowed or expelled; however, these reviews did not specifically consider marine mammals.

Based on the small size of chaff fibers, it appears unlikely that marine mammals would confuse the fibers with prey or purposefully feed on chaff fibers. However, marine mammals could occasionally ingest low concentrations of chaff incidentally from the surface, water column, or seafloor. While no studies were conducted to evaluate the effects of chaff ingestion on marine mammals, the effects are expected to be negligible, based on the low concentrations that could reasonably be ingested, the small size of chaff fibers, and available data on the toxicity of chaff and aluminum. In laboratory studies conducted by the University of Delaware (Hullar et al. 1999), blue crabs and killifish were fed a food-chaff mixture daily for several weeks, and no significant mortality was observed at the highest exposure treatment. Similar results were found when chaff was added directly to exposure chambers containing filter-feeding menhaden. Histological examination indicated no damage from chaff exposures. A study on calves that were fed chaff found no evidence of digestive disturbance or other clinical symptoms (U.S. Air Force 1997).

Chaff cartridge plastic end caps and pistons would also be released into the marine environment, where they would persist for long periods and could be ingested by marine mammals. Chaff end caps and pistons sink in saltwater (Spargo 2007), which reduces the likelihood of ingestion by marine mammals at the surface or in the water column.

Flares

Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic end cap and piston (approximately 1.4 in. [3.6 cm] in diameter).

An extensive literature review and controlled experiments conducted by the U.S. Air Force demonstrated that self-protection flare use poses little risk to the environment or animals (U.S. Air Force 1997). Nonetheless, marine mammals within the vicinity of flares could be exposed to light generated by the flares. Pistons and end caps from flares would have the same impact on marine mammals as discussed under chaff cartridges. It is unlikely that marine mammals would be exposed to any chemicals that produce either flames or smoke since these components are consumed in their entirety during the burning process. Animals are unlikely to approach or get close enough to the flame to be exposed to any chemical components.

Decelerators/Parachutes

Aircraft-launched sonobuoys, lightweight torpedoes (such as the MK 46 and MK 54) and targets use nylon decelerators/parachutes ranging in size from 18 to 48 in. (46 to 122 cm) in diameter. The majority of expended decelerators/parachutes are cruciform decelerators associated with sonobuoys, which are relatively small, and have short attachment lines. Decelerators/parachutes are made up of cloth and nylon, with weights attached to the lines for rapid sinking upon impact with the water. At water impact, the decelerator/parachute assembly is expended, and it sinks away from the unit. The decelerator/parachute assembly may remain at the surface for a short time before it and its housing sink to the seafloor, where it becomes flattened (Environmental Sciences Group 2005). Some decelerators/parachutes are weighted with metal clips to hasten their descent to the seafloor.

Ingestion of a decelerator/parachute by a marine mammal at the surface or within the water column would be unlikely, since the decelerator/parachute would not be available for very long before it sinks. Once on the seafloor, if bottom currents are present, the fabric cruciform panel may temporarily billow and be available for potential ingestion by marine animals with bottom-feeding habits.

Based on the information summarized above in 3.4.4.6 (Ingestion Stressors), mysticetes found within the Study Area, with the potential exception of humpback whale and minke whale, are not expected to encounter decelerators/parachutes on the seafloor. Ingestion of decelerators/parachutes by odontocetes feeding off the bottom is unlikely. If ingestion were to occur, it would be incidental with decelerators/parachutes potentially consumed along with bottom-dwelling prey.

3.4.4.6.4.1 No Action Alternative

Training Activities

As discussed in Section 3.4.4.6 (Ingestion Stressors), under the No Action Alternative, training activities would release military expended materials other than munitions in the Study Area. Target-related material, chaff, flares, decelerators/parachutes, and their subcomponents have the potential to be ingested by a marine mammal. Although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

Under the No Action Alternative, approximately 19,700 military expended materials other than munitions would be used during training activities. Approximately 60 percent of these items are chaff and flares, all of which would be expended in deep waters beyond 12 nm from shore. The smaller items discussed here may pose a hazard to marine mammals; however, as discussed in Section 3.4.4.6.3 (Impacts from Munitions), the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event.
- The limited period of time these military expended materials would remain in the water column.
- The unlikely chance that a marine mammal might encounter and swallow these items on the sea floor, particularly given that many of these items would be expended over deep, offshore waters.
- The ability of many marine mammals to reject and not swallow non-food items incidentally ingested.

The impacts of ingesting military expended materials other than munitions would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of decelerators/parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials other than munitions during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), there are no testing activities proposed under the No Action Alternative that would use military expended materials in the Study Area.

3.4.4.6.4.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

As discussed in Section 3.4.4.6 (Ingestion Stressors), under Alternative 1, training activities would release military expended materials other than munitions in the Study Area. Target-related material, chaff, flares, decelerators/parachutes, and their subcomponents have the potential to be ingested by a marine mammal. Although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

Under Alternative 1, approximately 63,000 military expended materials other than munitions would be used during training activities. Approximately 80 percent of these items are chaff and flares, all of which would be expended in deep waters beyond 12 nm from shore. Overall, this would be a 220 percent increase over the number of military expended materials other than munitions proposed under the No Action Alternative.

The smaller items discussed here may pose a hazard to marine mammals; however, as discussed in Section 3.4.4.6.3 (Impacts from Munitions), the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event.
- The limited period of time these military expended materials would remain in the water column.
- The unlikely chance that a marine mammal might encounter and swallow these items on the sea floor, particularly given that many of these items would be expended over deep, offshore waters.
- The ability of many marine mammals to reject and not swallow non-food items incidentally ingested.

The impacts of ingesting military expended materials other than munitions would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of decelerators/parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials other than munitions during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 1, testing activities involving military expended materials other than munitions take place in the Study Area.

Under Alternative 1, approximately 3,000 military expended materials other than munitions would be used during testing activities. Approximately 60 percent of these items are decelerators/parachutes and 30 percent are chaff and flares. The remaining 10 percent are targets. The number of military expended materials used under Alternative 1 is an increase over the number proposed under the No Action Alternative, because there are no testing activities under the No Action Alternative that would use these materials.

Decelerators/parachutes, chaff, flares, and fragments from targets have the potential to be ingested by marine mammals. Although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam and other small items may float for some time before sinking.

The smaller items discussed here may pose a hazard to marine mammals; however, as discussed in Section 3.4.4.6.3 (Impacts from Munitions), the impacts from ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event.
- The limited period of time these military expended materials would remain in the water column.
- The unlikely chance that a marine mammal might encounter and swallow these items on the sea floor, particularly given that many of these items would be expended over deep, offshore waters.
- The ability of many marine mammals to reject and not swallow non-food items incidentally ingested.

The impacts of ingesting military expended materials other than munitions would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of decelerators/parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials other than munitions during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.6.4.3 Alternative 2

<u>Training Activities</u>

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities.

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 2, training activities would release military expended materials other than munitions in the Study Area. Target-related material, chaff, flares, decelerators/parachutes, and their subcomponents have the potential to be ingested by a marine mammal. Although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

Under Alternative 2, approximately 68,000 military expended materials other than munitions would be used during training activities. Approximately 80 percent of these items are chaff and flares, all of which would be expended in deep waters beyond 12 nm from shore. Overall, this would be a 250 percent increase over the number of military expended materials other than munitions proposed under the No Action Alternative and a 10 percent increase over Alternative 1.

The smaller items discussed here may pose a hazard to marine mammals; however, as discussed in Section 3.4.4.6.3 (Impacts from Munitions), the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event.
- The limited period of time these military expended materials would remain in the water column.
- The unlikely chance that a marine mammal might encounter and swallow these items on the sea floor, particularly given that many of these items would be expended over deep, offshore waters.
- The ability of many marine mammals to reject and not swallow non-food items incidentally ingested.

The impacts of ingesting military expended materials other than munitions would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of decelerators/parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials other than munitions during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 2, testing activities involving military expended materials other than munitions take place in the Study Area.

Under Alternative 2, approximately 3,200 military expended materials other than munitions would be used during testing activities. Approximately 60 percent of these items are decelerators/parachutes and 30 percent are chaff and flares. The remaining 10 percent are targets. The number of military expended materials used under Alternative 2 is an increase over the number proposed under the No Action Alternative, because there are no testing activities under the No Action Alternative that would use these materials. The number of military expended materials proposed under Alternative 2 is an increase of approximately 10 percent over the number proposed under Alternative 1.

Decelerators/parachutes, chaff, flares, and fragments from targets have the potential to be ingested by a marine mammal. Although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam and other small items may float for some time before sinking.

The smaller items discussed here may pose a hazard to marine mammals; however, as discussed in Section 3.4.4.6.3 (Impacts from Munitions), the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event.
- The limited period of time these military expended materials would remain in the water column.
- The unlikely chance that a marine mammal might encounter and swallow these items on the sea floor, particularly given that many of these items would be expended over deep, offshore waters.
- The ability of many marine mammals to reject and not swallow non-food items incidentally ingested.

The impacts of ingesting military expended materials other than munitions would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of decelerators/parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials other than munitions during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.7 Secondary Stressors

This section analyzes potential impacts to marine mammals exposed to stressors indirectly through effects on habitat and prey availability from impacts associated with sediments and water quality. For the purposes of this analysis, indirect impacts to marine mammals via sediment or water that do not require trophic transfer (e.g., bioaccumulation) in order to be observed are considered here. It is important to note that the terms "indirect" and "secondary" do not imply reduced severity of environmental consequences, but instead describe how the impact may occur in an organism. Additionally, the transportation of marine mammals (the Navy's marine mammal system) in association with Force Protection and Mine Warfare events is presented to detail the lack of potential for the introduction of disease or parasites from those marine mammals to the Study Area. The potential for impacts from all of these secondary stressors are discussed below.

Stressors from military training and testing activities could pose indirect impacts to marine mammals via habitat degradation or an effect on prey availability. The stressors include (1) explosives, (2) explosive byproducts and unexploded ordnance, (3) metals, (4) chemicals, and (5) transmission of marine mammal diseases and parasites. Analyses of the potential impacts to sediments and water quality are discussed in Section 3.1 (Sediments and Water Quality).

3.4.4.7.1 Explosives

In addition to directly impacting marine mammals, underwater explosions could impact other species in the food web, including prey species that marine mammals feed upon. The impacts of explosions would differ depending upon the type of prey species in the area of the blast.

In addition to physical effects of an underwater blast, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to explosions that might include swimming to the surface or scattering away from the source. This startle and flight response is the most common secondary defense among animals (Hanlon and Messenger 1996). The abundances of prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. Alternatively, any prey species that would be directly injured or killed by the blast could draw in scavengers from the surrounding waters that would feed on those organisms, and in turn could be susceptible to becoming directly injured or killed by subsequent explosions. Any of these scenarios would be temporary, only occurring during activities involving explosives, and no lasting effect on prey availability or the pelagic food web would be expected.

3.4.4.7.2 Explosive Byproducts and Unexploded Ordnance

High-order explosions consume most of the explosive material, creating typical combustion products. In the case of Royal Demolition Explosive, 98 percent of the products are common seawater constituents, and the remainder is rapidly diluted below threshold effect level (Section 3.1, Sediments and Water Quality, Table 3.1-9). Explosive byproducts associated with high order detonations present no indirect stressors to marine mammals through sediment or water. However, low-order detonations and unexploded ordnance present elevated likelihood of impacts to marine mammals.

Deposition of undetonated explosive materials into the marine environment can be reasonably well estimated by the known failure and low-order detonation rates of explosives (Section 3.1, Sediments and Water Quality, Table 3.1-5). Marine mammals may be exposed by contact with the explosive, contact with contaminants in the sediment or water, and ingestion of contaminated sediments.

Indirect impacts of explosives and unexploded ordnance to marine mammals via sediment is possible in the immediate vicinity of the ordnance. Degradation of explosives proceeds through several pathways is discussed in Section 3.1.3.1 (Explosives and Explosive Byproducts). Degradation products of Royal

Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Rosen and Lotufo 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6–12 in. (0.15–0.3 m) away from degrading ordnance, the concentrations of these compounds were not statistically distinguishable from background beyond 3–6 ft. (1–2 m) from the degrading ordnance (Section 3.1.3.1, Explosives and Explosive Byproducts). Taken together, it is possible that marine mammals could be exposed to degrading explosives, but it would be within a very small radius of the explosive (1–6 ft. [0.3–2 m]).

In 2010, an investigation of a World War II underwater munitions disposal site in Hawaii (University of Hawai'i 2010) provides information in this regard. Among the purposes of the investigation were to determine whether these munitions, which had been on the seafloor for approximately 75 years, had released constituents (including explosive components and metals) that could be detected in sediment, seawater, or marine life nearby and whether there were significant ecological differences between the dump site and a “clean” reference site. Samples analyzed showed no confirmed detection for explosives. For metals, although there were localized elevated levels of arsenic and lead in several biota samples and in the sediment adjacent to the munitions, the origin of those metals could not be definitively linked to the munitions since comparison of sediment between the clean reference site and the disposal site both had relatively little anthropogenic component, and especially in comparison to samples for ocean disposed dredge spoils sites (locations where material taken from the dredging of harbors on Oahu was disposed). Observations and data collected also did not indicate any adverse impact on the ecology of the dump site.

Given that the concentration of munitions/explosions, expended material, or devices would never exceed that of a World War II dump site in any of the proposed actions, the water quality effects from the use of munitions, expended material, or devices would be negligible and would have no long-term effect on water quality and therefore would not constitute a secondary indirect stressor for marine mammals.

3.4.4.7.3 Metals

Metals are introduced into seawater and sediments as a result of training and testing activities involving ship hulks, targets, ordnance, munitions, and other military expended materials (Section 3.1.3.2, Metals). Some metals bioaccumulate, and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals (see Section 3.3, Marine Habitats, and Section 4.0, Cumulative Impacts). Indirect impacts of metals to marine mammals via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. Marine mammals may be exposed by contact with the metal, contact with contaminants in the sediment or water, and ingestion of contaminated sediments. Concentrations of metals in sea water are orders of magnitude lower than concentrations in marine sediments. It is extremely unlikely that marine mammals would be indirectly impacted by metals via the water and few marine mammal species feed primarily on the seafloor where they would come into contact with marine sediments.

3.4.4.7.4 Chemicals

Several military training and testing activities introduce potentially harmful chemicals into the marine environment; principally, flares and propellants for rockets, missiles, and torpedoes. Properly functioning flares missiles, rockets, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment. The greatest risk to marine mammals would be from perchlorate released from flares, missile, and rockets that operationally fail. Perchlorate is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals. Marine mammals could be exposed to water containing perchlorate if in an area when and where one of these failed items occurred. However, rapid dilution would occur, and toxic concentrations are unlikely to be encountered in seawater.

3.4.4.7.5 Transmission of Marine Mammal Diseases and Parasites

The U.S. Navy deploys trained Atlantic bottlenose dolphins (*Tursiops truncatus*) and California sea lions (*Zalophus californianus*) for integrated training involving two primary mission areas; to find objects such as inert mine shapes, and to detect swimmers or other intruders around Navy facilities such as piers. When deployed, the animals are part of what the Navy refers to as Marine Mammal Systems. These Marine Mammal Systems include one or more motorized small boats, several crew members, and a trained marine mammal. Based on the standard procedures with which these systems are deployed, it is not reasonably foreseeable that use of these marine mammals systems would result in the transmission of disease or parasites to cetacea or pinniped in the Study Area based on the following.

Each trained animal is deployed under behavioral control to find the intruding swimmer or submerged object. Upon finding the 'target' of the search, the animal returns to the boat and alerts the animal handlers that an object or swimmer has been detected. In the case of a detected object, the human handlers give the animal a marker that the animal can bite onto and carry down to place near the detected object. In the case of a detected swimmer, animals are given a localization marker or leg cuff that they are trained to deploy via a pressure trigger. After deploying the localization marker or leg cuff the animal swims free of the area to return to the animal support boat. For detected objects, human divers or remote vehicles are deployed to recover the item. Swimmers that have been marked with a leg cuff are reeled-in by security support boat personnel via a line attached to the cuff.

Marine mammal systems deploy approximately 1–2 weeks before the beginning of a training exercise to allow the animals to acclimate to the local environment. There are 4–12 marine mammals involved per exercise. Systems typically participate in object detection and recovery, both participating in mine warfare events, and assisting with the recovery of inert mine shapes at the conclusion of an event. Marine Mammal Systems may also participate in port security and anti-terrorism/force protection events.

During the past 40 years, the Navy Marine Mammal Program has deployed globally. To date, there have been no known instances of deployment-associated disease transfer to or from Navy marine mammals. Navy animals are maintained under the control of animal handlers and are prevented from having sustained contact with indigenous animals.

When not engaged in the training event, Navy Marine Mammals are either housed in temporary enclosures or aboard ships involved in training exercises. All marine mammal waste is disposed of in a manner approved for the specific holding facilities. When working, sea lions are transported in boats and dolphins are transferred in boats or by swimming along-side the boat under the handler’s control. Their open-ocean time is under stimulus control and is monitored by their trainers.

Navy marine mammals receive excellent veterinarian care (per SECNAVINST 3900.41E). Appendix A, Section 8, of the Swimmer Interdiction Security System Final EIS (U.S. Department of the Navy 2009) provides an overview of the veterinary care provided for the Navy's marine mammals. Appendix B, Section 2, of the Swimmer Interdiction Security System Final EIS provides detailed information on the health screening process for communicable diseases. The following is a brief summary of the care received by all of the Navy's marine mammals:

1. Qualified veterinarians conduct routine and pre-deployment health examinations on the Navy's marine mammals; only animals determined as healthy are allowed to deploy.
2. Restaurant-quality frozen fish are fed to prevent diseases that can be caused by ingesting fresh fish (e.g., parasitic diseases).
3. Navy animals are routinely dewormed to prevent parasitic and protozoal diseases.
4. If a valid and reliable screening test is available for a regionally relevant pathogen (e.g., polymerase chain reaction assays for morbillivirus), such tests are run on appropriate animal samples to ensure that animals are not shedding these pathogens.

The Navy Marine Mammal Program routinely does the following to further mitigate the low risk of disease transmission from captive to wild marine mammals during training events:

1. Marine mammal waste is disposed of in an approved system dependent upon the animal's specific housing enclosure and location.
2. Onsite personnel are made aware of the potential for disease transfer, and report any sightings of wild marine mammals so that all personnel are alert to the presence of the animal.
3. Marine mammal handlers visually scan for indigenous marine animals, for at least 5 minutes before animals are deployed and maintain a vigilant watch while the animal is working in the water. If a wild marine mammal is seen approaching or within 100 m, the animal handler will hold the marine mammal in the boat or recall the animal immediately if the animal has already been sent on the mission.
4. The Navy obtains appropriate state agriculture and other necessary permits and strictly adheres to the conditions of the permit.

Due to the very small amount of time that the Navy marine mammals spend in the open ocean; the control that the trainers have over the animals; the collection and proper disposal of marine mammal waste; the exceptional screening and veterinarian care given to the Navy's animals; the visual monitoring for indigenous marine mammals; and an over 40-year track record with zero known incidents, there is no scientific basis to conclude that the use of Navy marine mammals during training activities would have an impact on wild marine mammals.

3.4.4.7.6 No Action Alternative, Alternative 1, and Alternative 2

<u>Training Activities</u>

Pursuant to the MMPA, secondary stressors from training activities under the No Action Alternative, Alternative 1, and Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, secondary stressors from training activities under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but are not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

Pursuant to the MMPA, secondary stressors from testing activities under the No Action Alternative, Alternative 1, and Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, secondary stressors from testing activities under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but are not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.5 SUMMARY OF IMPACTS ON MARINE MAMMALS

3.4.5.1 Combined Impacts of All Stressors

As described in Section 3.0.5.4 (Resource-Specific Impacts Analysis for Multiple Stressors), this section evaluates the potential for combined impacts of all the stressors from the proposed action. The analysis and conclusions for the potential impacts from each of the individual stressors are discussed in the analyses of each stressor in the sections above and summarized in Sections 3.4.5.3 (Marine Mammal Protection Act Determinations), and 3.4.5.4 (Endangered Species Act Determinations).

There are generally two ways that a marine mammal could be exposed to multiple stressors. The first would be if a marine mammal were exposed to multiple sources of stress from a single event or activity (e.g., a mine warfare event may include the use of a sound source and a vessel). The potential for a combination of these impacts from a single activity would depend on the range to effects of each of the stressors and the response or lack of response to that stressor. Most of the activities as described in the proposed action involve multiple stressors; therefore it is likely that if a marine mammal were within the potential impact range of those activities, they may be impacted by multiple stressors simultaneously. This would be even more likely to occur during large-scale exercises or events that span a period of days or weeks (such as a sinking exercise or composite training unit exercise).

Secondly, a marine mammal could be exposed to a combination of stressors from multiple activities over the course of its life; however, combinations are unlikely to co-occur because training and testing activities are generally separated in space and time in such a way that it would be very unlikely that any individual marine mammal would be exposed to stressors from multiple activities. However, animals with a home range intersecting an area of concentrated Navy activity have elevated exposure risks relative to animals that simply transit the area through a migratory corridor. The majority of the proposed activities are unit level. Unit level events occur over a small spatial scale (one to a few square miles) and with few participants (usually one or two) or short duration (the order of a few hours or less). Time is a factor with respect to the probability of exposure. Because most Navy stressors persist for a time shorter than or equal to the duration of the activity, the odds of exposure to combined stressors is lower than would be the case for persistent stressors. For example, strike stressors cease with the passage of the object; ingestion stressors cease (mostly) when the object settles to the seafloor. The animal would have to be present during each of the brief windows that the stressors exist.

Multiple stressors may also have synergistic effects. For example, marine mammals that experience temporary hearing loss or injury from acoustic stressors could be more susceptible to physical strike and disturbance stressors via a decreased ability to detect and avoid threats. Marine mammals that experience behavioral and physiological consequences of ingestion stressors could be more susceptible to entanglement and physical strike stressors via malnourishment and disorientation. These interactions are speculative, and without data on the combination of multiple Navy stressors, the synergistic impacts from the combination of Navy stressors are difficult to predict in any meaningful way. Navy research and monitoring efforts include data collection through conducting long-term studies in areas of Navy activity, occurrence surveys over large geographic areas, biopsy of animals occurring in areas of Navy activity, and tagging studies where animals are exposed to Navy stressors. These efforts are intended to contribute to the overall understanding of what impacts may be occurring overall to animals in these areas. Starting in 2015, specific allocation of monitoring effort (research objectives, studies, and focus) within the Study Area will be included in a monitoring plan to be developed in cooperation with NMFS.

U.S. Navy-funded monitoring results from surveys conducted in the Study Area

From 2010 through December 2013, Navy-funded marine mammal surveys in the Study Area completed over 1,979 hours of on-effort visual surveys covering over 35,538 km, and resulting in the sighting of over 358 cetacean groups. Species identified included bottlenose, pan-tropical spotted, and spinner dolphins; and sperm, short-finned pilot, pygmy killer and dwarf sperm whales. Over 53,668 photographs were taken, and eight passive acoustic monitoring devices were deployed around the Mariana Islands for detecting and identifying marine mammals by their calls. Additionally, 10 satellite tags have been deployed on dolphins and small whales in the Marianas, and 189 biopsies have been collected for genetic analysis. Acoustic data analysis is ongoing on Navy and NMFS (Pacific Islands Fisheries Science Center) archived data sets.

3.4.5.2 Summary of Observations During Previous Navy Activities

Since 2006, the Navy, non-Navy marine mammal scientists, and research institutions have conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where the Navy has been and proposes to continue training and testing. Data collected from Navy monitoring, scientific research findings, and annual reports have been provided to NMFS[8] and may provide information relevant to the analysis of impacts to marine mammals for a variety of reasons, including data on species distribution, habitat use, and evaluating potential animal responses to Navy activities. Monitoring is performed using a variety of methods, including visual surveys from surface vessels and aircraft, as well as passive acoustics. Navy monitoring can generally be divided into two types of efforts: (1) collecting long-term data on distribution, abundance, and habitat use patterns within Navy activity areas; and (2) collecting data during individual training or testing activities. Navy also contributes to funding of basic research, including behavioral response studies specifically designed to determine the effects to marine mammals from the Navy's main mid-frequency surface ship anti-submarine warfare active acoustic (sonar) system.

The majority of the training and testing activities the military is proposing for the next five years are similar if not identical to activities that have been occurring in the same locations for decades. For example, the mid-frequency sonar system on the cruisers, destroyers, and frigates has the same sonar system components in the water as was first deployed in the 1970s. While the signal analysis and

[8] Navy monitoring reports are available at the Navy website, www.navymarinespeciesmonitoring.us/, and also at the NMFS website; www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

computing processes onboard these ships have been upgraded with modern technology, the power and output of the sonar transducer, which puts signals into the water, have not changed. For this reason, the history of past marine mammal observations, research, and monitoring reports remain applicable to the analysis of effects from the proposed future training and testing activities. In addition, because there is a longer (6-year) record of monitoring Navy activities in the Pacific and because there is more available science specific to the areas where Navy has historically trained and tested in waters off the California coast and Hawaii, the research and monitoring record from those areas is informative with regard to assessing the effects of military training and testing in general.

In the Mariana Islands, the first exercise-related investigation involved an aerial monitoring survey after the Valiant Shield training exercise in July 2007. That survey covered 2,352 km of linear effort. There were no reports of strandings, distressed, or injured animals during that survey effort (Mobley 2007) and stranded animals in the Mariana Islands have never been reported in association with military activities. Regular monitoring for compliance with the ESA and MMPA consultation began in 2010. Forty sightings of marine mammals were reported by Navy Lookouts aboard Navy ships within the Study Area from 2009 to 2013, as presented in the Annual Marine Species Monitoring Reports submitted to NMFS and Navy Exercise Reports (e.g., U.S. Department of the Navy 2011 and additional reports at the website cited in the reference citation and footnote below). During these observations, mainly from major training exercises, there were no reported observations of adverse reactions by marine mammals.

The Navy and NMFS determined during the permitting process that monitoring in the Study Area should focus on augmenting existing baseline data, such as the data the Navy proactively collected during the large-vessel MISTCS (Fulling et al. 2011; Norris et al. 2012), instead of focusing on exercise monitoring in Guam and the Mariana Islands. The Navy's Scientific Advisory Group (SAG) concurred with this approach, and a regional SAG meeting specific to monitoring in the MIRC was conducted in October 2011 to help shape the current monitoring plan. The monitoring plan, therefore, presently includes small vessel surveys, satellite tagging, biopsy, photo-identification, passive acoustic monitoring, and acoustic data analysis. The results from the Navy's monitoring efforts to date have been posted on the NMFS' Office of Protected Resources website as well as on the Navy's Marine Species Monitoring website.[9]

In the Mariana Islands, Navy-funded marine species monitoring has included small vessel surveys, tagging, biopsy, and photo-identification during 2010, 2011, 2012, and 2013 off Guam, Saipan, Tinian, Rota, and Aguigan, as well as the deployment of passive acoustic monitoring devices and analysis of acoustic data. The monitoring efforts in the MIRC beginning in 2013 have been adjusted using the Adaptive Management Process in coordination with NMFS to structure the monitoring plan based on scientific monitoring questions rather than metrics of effort for each monitoring methodology. In addition to the Navy-funded monitoring described above, the Navy also co-funded additional visual surveys conducted by the NMFS' Pacific Islands Fisheries Science Center from 2009 to 2013. U.S. Pacific Fleet funding in the Study Area as part of the overall Navywide funding in marine mammal research and monitoring programs was over $3.4 million from 2010 to 2013.

Navy-funded marine species surveys in the Action Area from February 2011 through December 2013 completed more than 1,979 hours of on-effort visual surveys covering over 35,538 km and resulting in the sighting of 358 marine mammal groups. Species identified included bottlenose, pan-tropical spotted, and spinner dolphins; and sperm, short-finned pilot, pygmy killer, and dwarf sperm whales. More than

[9] www.navymarinespeciesmonitoring.us

53,668 photographs were taken, and eight passive acoustic monitoring devices were deployed around the Mariana Islands for detecting and identifying marine mammals by their calls. Additionally, 10 satellite tags have been deployed on dolphins and small whales in the Marianas, and 189 biopsies have been collected for genetic analysis. Acoustic data analysis is ongoing on Navy and NMFS (Pacific Islands Fisheries Science Center) archived data sets.

The small boat surveys conducted by the Pacific Islands Fisheries Science Center around Guam and the CNMI, include: (1) surveys off Guam and Saipan from 9 February to 3 March 2010 (Oleson and Hill 2010; Ligon et al. 2011), (2) surveys off Guam from 17 February to 3 March 2011 (HDR 2011), (3) surveys off Guam and other islands in the CNMI from 26 August to 29 September 2011 (Hill et al. 2012), (4) surveys off Guam and Saipan from 15 to 29 March 2012 (HDR EOC 2012), and (5) surveys off Guam and other islands in the CNMI at various times between May and July 2012 (Hill et al. 2013). In addition, the Pacific Islands Fisheries Science Center conducted a large vessel cetacean and oceanographic survey between Honolulu and Guam and within the EEZs of Guam and CNMI from 20 January to 3 May 2010 (Oleson and Hill 2010).

Hill et al. (2013) reported 17 cetacean sightings during 11 surveys off Guam and 20 cetacean sightings over the course of 20 surveys off the CNMI. Species sighted off Guam included bottlenose dolphins, spinner dolphins, pantropical spotted dolphins, and short-finned pilot whales. During the 20 surveys within waters less than 32 nm from shore in the CNMI, 22 cetacean sightings were recorded. Seventy-two percent of sightings in waters of the CNMI occurred in the waters surrounding the islands of Saipan, Tinian, and Aguijan. However, the encounter rate around the island of Rota was greater than elsewhere in the survey area, and species sighted at Rota were in approximately the same location when they were sighted during surveys conducted in 2011, suggesting that the area is consistently used by those species. Ligon et al. (2011) reported data on sightings over a total of 16 days, 10 of which were conducted off Guam, and 6 off Saipan. The researchers reported 18 sightings consisting of three identified species: spinner dolphin, sperm whale, and pantropical spotted dolphin. The pantropical spotted dolphins were only spotted off Guam, whereas the other species were sighted off both Guam and Saipan. A survey off the western and northern coasts of Guam in February and March of 2011 recorded nine cetacean sightings consisting of seven groups of spinner dolphins, one mixed-species group of short-finned pilot whales and bottlenose dolphins, and one unidentified small dolphin (HDR 2011). The large scale survey conducted by Oleson and Hill (2010) was divided into four components: (1) a survey along a transit route from Hawaii to Guam, (2) a survey of waters around Micronesia and the CNMI, (3) a survey along a transit route from Guam to Hawaii, and (4) a small-boat survey of the waters surrounding Guam, Saipan, and Tinian. Combined, the four surveys were conducted over 62 days, spanned over 4,000 nm, reported sightings of 73 cetacean groups, compiled over 5,500 photographs, and took 13 biopsies. Hill et al. (2012) conducted small boat surveys of the waters surrounding Guam and the islands of Saipan, Tinian, Rota, and Aguijan in the CNMI. Eight cetacean groups were sighted during the nine surveys conducted off Guam. The species sighted included bottlenose dolphin, spinner dolphin, pantropical spotted dolphin, and short-finned pilot whale. Spinner dolphins were the most frequently encountered species. During the 21 surveys conducted in the CNMI waters, 30 sightings of cetacean groups were recorded. The species encountered included the same four species sighted off Guam as well as pygmy killer whales and a dwarf sperm whale. The species-specific subsections of Section 3.4.2 (Affected Environment) provide additional details on these recent surveys.

Observations from research occurring in the other Navy range complexes (e.g., HRC, SOCAL, and Atlantic Fleet Active Sonar Training [known as AFAST]) are also discussed in this section and demonstrate a continued commitment to expanding the knowledge of marine mammal occurrence and abundance in

Navy operating areas. In the Pacific, the vast majority of scientific field work, research, and monitoring efforts have been expended in Southern California and Hawaii where Navy has historically concentrated training and testing activities. Since 2006, across all Navy Range Complexes (in the Atlantic, Gulf of Mexico, and the Pacific), there have been a total of 69 reports (Major Exercise Reports, Annual Exercise Reports, and Annual Monitoring Reports; Table 3.4-26) submitted to NMFS to further research goals aimed at understanding Navy's impact on the environment as it carries out its mission to train and test. In addition to this multi-year record of reports from across the Navy, there has also been ongoing behavioral response research efforts (in Southern California and the Bahamas) specifically focused on determining the potential effects from Navy mid-frequency sonar (De Ruiter et al. 2013a, Goldbogen et al. 2013, Tyack et al. 2011). This multi-year compendium of monitoring, observation, study, and broad scientific research is informative with regard to assessing the effects of military training and testing in general. Given this record involves the same military training and testing activities being considered for the MITT Study Area and includes all the marine mammal taxonomic families present and many of the same species as those expected within the MITT Study Area, this broad record covering Navy activities elsewhere is applicable to assessing locations such as the Mariana Islands.

In the Hawaii and Southern California Navy training and testing ranges from 2009 to 2012, Navy-funded marine mammal monitoring research completed over 5,000 hours of visual survey effort covering over 65,000 nm, sighted over 256,000 individual marine mammals, took more than 45,600 digital photos and 36 hours of digital video, attached 70 satellite tracking tags to individual marine mammals, and collected over 40,000 hours of passive acoustic recordings. In Hawaii alone between 2006 and 2012, there were 21 scientific marine mammal surveys conducted before, during, or after major exercises.

Table 3.4-26: Navy Reporting of Monitoring and Major Exercises

Year Submitted	Range	Document
2006	Hawaii Range Complex	RIMPAC 06 Exercise After Action Report
2007	Mariana Islands Range Complex	Marine Mammal Monitoring Surveys in Support of "Valiant Shield" Training Exercises
	Mariana Islands Range Complex	Valiant Shield Exercise After Action Report
	Hawaii Range Complex	Undersea Warfare Training Exercise (USWEX) After Action Report
2008	Southern California Range Complex	Composite Training Unit Exercise 08-1, Oct–Nov 2007
	Hawaii Range Complex	Undersea Warfare Training Exercise (USWEX) After Action Report
	Hawaii Range Complex	Aerial Surveys of Marine Mammals Performed in Support of USWEX Exercises
	Hawaii Range Complex	RIMPAC 08 Exercise After Action Report
	Hawaii Range Complex	Marine Mammal and Sea Turtle Monitoring Survey in Support of Navy Training Exercises in the Hawaii Range Complex
	Cherry Point and Charleston/Jacksonville Operating Areas	USS Nassau Expeditionary Strike Group Composite Training Unit Exercise 08-01
2009	Southern California Range Complex	Annual Range Complex Exercise Report, January–August 2009
	Hawaii Range Complex and Southern California Range Complex	Marine Mammal Monitoring, Annual Report 2009
	Atlantic Fleet Active Sonar Training Study Area	Annual Range Complex Exercise Report, January–August 2009
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Annual Range Complex Exercise Report (Explosive Training Activities), 2009
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Marine Mammal Monitoring, Annual Report 2009
	Jacksonville Range Complex	Cruise Report, Marine Mammal Monitoring, UNITAS GOLD 2009

Table 3.4-26: Navy Reporting of Monitoring and Major Exercises (continued)

Year Submitted	Range	Document
2010	Atlantic Fleet Active Sonar Training Study Area	Marine Species Monitoring, Annual Report for 2009
	Southern California Range Complex and Hawaii Range Complex	Annual Range Complex Exercise Report, August 2009–August 2010
	Hawaii Range Complex and Southern California Range Complex	Marine Mammal Monitoring, 2010 Annual Report
	Atlantic Fleet Active Sonar Training Study Area	Annual Range Complex Exercise Report, August 2009–August 2010
	Atlantic Fleet Active Sonar Training Study Area	Marine Species Monitoring, Annual Report for 2010
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Annual Range Complex Exercise Report (Explosive Training Activities), 2010
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Marine Mammal Monitoring, Annual Report 2009
	Naval Surface Warfare Center Panama City Division Study Area	Marine Species Monitoring, Annual Report for 2010
	Naval Surface Warfare Center Panama City Division Study Area	Annual Mission Activities Report, 2010
2010	VACAPES Range Complex	Cruise Report, Marine Mammal Monitoring, Mine Neutralization Exercise Events, August 2009
	Jacksonville Range Complex	Jacksonville (JAX) Southeast Anti-Submarine Warfare Integration Training Initiative (SEASWITI) Marine Species Monitoring (2 reports: (1) Aerial Surveys and (2) Vessel) Surveys)
	Jacksonville Range Complex	Jacksonville (JAX) Gunnery Exercise (GUNEX), Marine Species Monitoring
	Jacksonville Range Complex	Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study, Southeastern Antisubmarine Warfare Integrated Training Initiative (SEASWITI), March 2010
	Jacksonville Range Complex	Jacksonville (JAX) MISSILEX, Marine Species Monitoring
	Jacksonville Range Complex	Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study, Southeastern Antisubmarine Warfare Integrated Training Initiative (SEASWITI), June 2010

Table 3.4-26: Navy Reporting of Monitoring and Major Exercises (continued)

Year Submitted	Range	Document
2011	Jacksonville Range Complex	Trip Report, FIREX Marine Mammal Monitoring
	Southern California Range Complex and Hawaii Range Complex	Annual Range Complex Exercise Report, August 2010–August 2011
	Hawaii Range Complex and Southern California Range Complex	Marine Mammal Monitoring, 2011 Annual Report
	Mariana Islands Range Complex	Annual Range Complex Exercise Report, August 2010–February 2011
	Mariana Islands Range Complex	Marine Species Monitoring, Annual Report
	Northwest Training Range Complex	Annual Range Complex Exercise Report, Year 1, November 2010–May 2011
	Northwest Training Range Complex	Annual Range Complex Monitoring Report, Year 1, November 2010–May 2011
	Atlantic Fleet Active Sonar Training Study Area	Annual Range Complex Exercise Report, August 2010–August 2011
	Atlantic Fleet Active Sonar Training Study Area	Marine Species Monitoring, Annual Report for 2011
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Annual Range Complex Exercise Report (Explosive Training Activities), 2010
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Marine Species Monitoring, Annual Report for 2010
	VACAPES Range Complex	Trip Report, Marine Mammal Monitoring, Mine Neutralization Exercise Event, August 2010
	VACAPES Range Complex	Virginia Capes (VACAPES) FIREX & ASW Training Events, Marine Species Monitoring
	VACAPES Range Complex	Virginia Capes (VACAPES) FIREX with IMPASS, Marine Species Monitoring
	VACAPES Range Complex	Virginia Capes (VACAPES) Anti-Submarine Warfare Exercise (ASWEX), Marine Species Monitoring
	Cherry Point Range Complex	Cherry Point (CHPT) Firing Exercise (FIREX) with Integrated Maritime Portable Acoustic Scoring and Simulator (IMPASS), Marine Species Monitoring
	Cherry Point Range Complex	Pamlico Sound Barge Sinking Event, Long Shoal Naval Ordnance Target and Scoring Tower Replacement, Marine Species Monitoring
	Jacksonville Range Complex	Jacksonville (JAX) Anti-Submarine Warfare Exercise (ASWEX), Marine Species Monitoring
	VACAPES Range Complex	Trip Report, Marine Mammal Monitoring, Mine Neutralization Exercise Event, Aug 2011

Table 3.4-26: Navy Reporting of Monitoring and Major Exercises (continued)

Year Submitted	Range	Document
2011	Keyport Range Complex	Annual Range Complex Exercise Report, Year 1, April 2011–September 2011
	Keyport Range Complex	Annual Range Complex Monitoring Report, Year 1, April 2011–November 2011
	Naval Surface Warfare Center Panama City Division Study Area	Marine Species Monitoring, Annual Report for 2011
	Naval Surface Warfare Center Panama City Division Study Area	Annual Mission Activities Report, 2011
	Northwest Training Range Complex	Annual Range Complex Exercise Report, Year 1, November 2010–May 2011
	Northwest Training Range Complex	Annual Range Complex Monitoring Report, Year 1, November 2010 –May 2011
	Gulf of Alaska	Annual Monitoring Report, 2011, Year 1
2012	Mariana Islands Range Complex	Annual Range Complex Exercise Report, 16 February 2011–15 February 2012
	Mariana Islands Range Complex	Marine Species Monitoring, Annual Report
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Annual Range Complex Exercise Report (Explosive Training Activities), 2011
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Marine Species Monitoring, Annual Report for 2011
	Jacksonville Range Complex	Jacksonville (JAX) Maverick Missile Exercise (MAVEX) Event, Marine Species Monitoring
	Jacksonville Range Complex	Cruise Report, Marine Mammal Monitoring, ASWEX
	Jacksonville Range Complex	Jacksonville (JAX) Firing Exercise (FIREX) with Integrated Maritime Portable Acoustic Scoring and Simulator (IMPASS), Marine Species Monitoring
	Southern California Range Complex	Marine Species Monitoring, 2012 Annual Report
	Hawaii Range Complex	Marine Species Monitoring, 2012 Annual Report
	Jacksonville Range Complex	An Analysis of Marine Acoustic Recording Unit (MARU) Data Collected off Jacksonville, Florida in Fall 2009 and Winter 2009–2010
	Northwest Training Range Complex	Annual Range Complex Unclassified Exercise Report
	Northwest Training Range Complex	Annual Range Complex Monitoring Report
	Northwest Training Range Complex	Environmental Monitoring Report, EOD/UNDET
2013	Mariana Islands Range Complex	Annual Range Complex Exercise Report, 2013
	Mariana Islands Range Complex	Marine Species Monitoring, Annual Report
	Naval Surface Warfare Center, Panama City Division	Testing AN/AQS-20A Mine Reconnaissance Sonar System in the Navy's NSWC PCD Testing Range, Marine Species Monitoring, Annual Report
2014	Mariana Islands Range Complex	Marine Species Monitoring, Annual Report
	Mariana Islands Range Complex	Annual Range Complex Exercise Report, 2014

Notes: (1) These reports are publically available at the Navy website (www.navymarinespeciesmonitoring.us/) and from the NMFS Office of Protected Resources website at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications. (2) NSWC = Naval Surface Warfare Center, PCD = Panama City Division.

The Navy has continued to review emergent science and fund research to better assess the potential impacts that may result from the continuation of ongoing training and testing in the historically used range complexes worldwide. Along with behavioral response studies and the results of research efforts and monitoring before, during, and after training and testing events across the Navy since 2006, the Navy's assessment is that it is unlikely there will be impacts to populations of marine mammals (such as whales, dolphins and porpoise) having any long-term consequences as a result of the proposed continuation of training and testing in the ocean areas historically used by the Navy including the Study Area.

This assessment of likelihood is based on four indicators from areas in the Pacific where Navy training and testing has been ongoing for decades: (1) evidence suggesting or documenting increases in the numbers of marine mammals present, (2) examples of documented presence and site fidelity of species and long-term residence by individual animals of some species, (3) use of training and testing areas for breeding and nursing activities, and (4) 6 years of comprehensive monitoring data indicating a lack of any observable effects to marine mammal populations as a result of Navy training and testing activities.[10] While there is evidence that shows increases and/or viability of marine mammal populations, there is no direct evidence from years of monitoring on Navy ranges that indicate any long-term consequences to marine mammal populations as a result of ongoing training and testing. Barring any evidence to the contrary, therefore, what limited and preliminary evidence there is from the Navy's 70 reports and other focused scientific investigations should be considered. This is especially the case given the widespread public misperception that Navy training and testing, especially involving use of mid-frequency sonar, would cause grave impacts and result in countless numbers of marine mammals being injured or killed. Examples to the contrary, which present results from studies conducted where the Navy has been training and testing for decades, can be found throughout the scientific literature.

Work by Moore and Barlow (2011) indicate that since 1991, there is strong evidence of increasing fin whale abundance in the California Current area, which includes offshore waters of the U.S. west coast up to the Canadian border. They predict continued increases in fin whale numbers over the next decade, and that perhaps fin whale densities are reaching "current ecosystem limits." Research by Falcone and Schorr (2012) suggests that fin whales may have population sub-units with higher-than-expected residency to the Southern California Bight, which includes part of the Navy's SOCAL Range Complex. Similar findings have also documented the seasonal range expansion and increasing presence of Bryde's whales south of Point Conception in Southern California (Kerosky et al. 2012; Smultea and Jefferson 2014). Findings from Smultea and Jefferson (2014) for these same waters off Southern California, including the SOCAL Range Complex, appear to show that since the 1950s, humpback whales and Risso's dolphins have increased in relative occurrence while common bottlenose and northern right whale dolphins; Dall's porpoise; and gray whales, killer whales, minke whales, Cuvier's beaked whales, and sperm whales do not appear to have changed. There is possible indication of recent decreased relative occurrence of the Pacific white-sided dolphin, and short-finned pilot whales have not been recorded in the area since the 1990s, concurrent with the observed relative increase in Risso's dolphins (Smultea and Jefferson 2014).

For the portion of the blue whale population in the Pacific (along the U.S. west coast) that includes Southern California as part of its range, there has been an upward trend in abundance (Calambokidis et

[10] Monitoring of Navy activities began in July 2006 as a requirement under issuance of an Incidental Harassment Authorization by NMFS for the Rim of the Pacific exercise and has continued to the present for Major Training Events in Hawaii, Southern California, and the Mariana Islands as well as other monitoring as part of the coordinated efforts under the Navy's Integrated Comprehensive Monitoring Plan developed in coordination with NMFS and other interested parties.

al. 2009b). Berman-Kowalewski et al. (2010) report that in 2007, the number of blue whales in the Santa Barbara Channel (just north of the Navy's SOCAL Range Complex) was at the highest count since 1992. For humpback whales that winter in the Hawaiian Islands, research has confirmed that the overall humpback whale population in the North Pacific has continued to increase and is now greater than some prior estimates of pre-whaling abundance (Barlow et al. 2011).The Hawaiian Islands, where the HRC has been located for decades, continue to function as a critical breeding, calving, and nursing area for this endangered species. National Marine Fisheries Service (2013) has recently proposed humpbacks in the North Pacific be delisted in light of strong indicators of their recovery.

As increases in population would seem to indicate, evidence for the presence or residence of marine mammal individuals and populations would also seem to suggest a lack of long-term or detrimental effects from Navy training and testing historically occurring in the same locations. For example, photographic records spanning more than two decades demonstrated there had been resightings of individual beaked whales (from two species: Cuvier's and Blainville's beaked whales), suggesting long-term site fidelity to the area west of the Island of Hawaii (McSweeney et al. 2007). This is specifically an area in the Hawaiian Islands where the Navy has been using mid-frequency sonar during anti-submarine warfare training (including relatively intense choke point or swept channel events) over many years. Passive acoustic detection of Blainsville's and Cuvier's beaked whales in waters surrounding Saipan as well as other areas of the Pacific Ocean (e.g., Wake Atoll and Palmyra Atoll) from 2005 to 2011 indicate long-term site fidelity in these areas as well (Baumann-Pickering et al. 2012). Similar findings of high site fidelity have been reported for the area west of Hawaii involving pygmy killer whales (*Feresa attenuata*) (McSweeney et al. 2009). Similarly, the intensively used instrumented range at PMRF remains the likely foraging area (given its proximity) for a resident pod of spinner dolphins that was the focus for part of the monitoring effort during the 2006 Rim of the Pacific Exercise. More recently at PMRF, Martin and Kok (2011) reported on the presence of minke whales, humpback whales, beaked whales, pilot whales, and sperm whales on or near the range during a Submarine Commander Course involving three surface ships and a submarine using mid-frequency sonar over the span of the multi-day event. The analysis showed it was possible to evaluate the behavioral response of minke whale and found there did not appear to be a significant reaction by the minke whale to the mid-frequency sonar transmissions (although overall minke calling rates were reduced during the training event). In subsequent analysis of the data set, Manzano-Roth et al. (2013) determined that beaked whales (tentatively identified as Blainville's beaked whales) continued to make foraging dives, but at reduced dive rates, at estimated distances of 13 to 52 km from active mid-frequency sonar. The animals shifted to the southern edge of the range and exhibited differences in the vocal period duration of the dive and dive rate. The estimated mean received level on the beaked whale group was 109 dB re 1 μPa)

Humpback whales are documented as the species which has received the highest sound pressure levels from training activities using U.S. Navy MFAS (i.e., at least 183 dB re 1 μPa) based upon an analysis which utilized shipboard Marine Mammal Observer sightings on 18 February 2011 (Farak et al 2011) combined with PMRF range hydrophone data (Martin and Manzano-Roth 2012). Analysis of PMRF hydrophone data for the purpose of estimating received levels on marine mammals has also been done in conjunction with satellite tagged animals (Baird et al. 2014) and aerial focal follows (i.e., when a single animal is tracked and observed; Mobley and Pacini 2013). Passive acoustic monitoring of PMRF hydrophones during Navy training for the month of February from 2011 to 2013 has shown that the number of acoustically identified minke whales is reduced during periods when MFAS is used compared to other periods of time (Martin et al. 2014, Martin et al. *in press*). Acoustic analysis has also shown that marine mammals near the sea surface can be exposed to higher estimated receive levels due to ducted sound propagation, which typically exists at PMRF. Behaviors observed during a focal follow aerial survey of a humpback whale in conjunction with estimated received levels derived from passive acoustic data are reported as a case study of a single focal follow occurring in the vicinity of MFAS (Mobley et al. 2013).

Sperm whales have been observed by marine mammal observers aboard Navy surface ships and detected by PMRF range hydrophones during Navy training events; however, MFAS was not active so no behavioural response data exists for naval training activities (Miller et al. 2012, Sivle et al. 2012). However, a sperm whale was tagged for a controlled exposure experiment during a behavioral response study at the range. The sperm whale did not appear to demonstrate obvious behavioral changes in dive pattern or production of clicks (Southall et al. 2011).

In Southern California, based on a series of surveys from 2006 to 2008 and the high number encounter rate, Falcone et al. (2009) proposed that their observations suggested the ocean basin west of San Clemente Island may be an important region for Cuvier's beaked whales. For over three decades, this ocean area west of San Clemente has been the location of the Navy's instrumented training range and is one of the most intensively used training and testing areas in the Pacific, given the proximity to the naval installations in San Diego. Data from visual surveys documenting the presence of Cuvier's beaked whales for the ocean basin west of San Clemente Island (Falcone et al. 2009; Falcone and Schorr 2012, 2014; Smultea and Jefferson 2014) are consistent with concurrent results from passive acoustic monitoring that estimated regional Cuvier's beaked whale densities were higher than indicated by the NMFS's broad scale visual surveys for the U.S. west coast (Hildebrand and McDonald 2009). Photo identification methods in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whales, with 40 percent having been seen in more than 1 year and with time spans between sightings of up to 7 years (Falcone and Schorr 2014). The Navy's use of the Southern California Range Complex has not precluded beaked whales from continuing to inhabit the area, nor has there been documented declines or beaked whale mortalities in the area associated with Navy training and testing activities. The long-term presence of beaked whales at the Navy range off Southern California is consistent with that for a similar Navy instrumented range (AUTEC) located off Andros Island in the Bahamas where Blainville's beaked whales (Mesoplodon densirostris) are routinely acoustically detected (see McCarthy et al. 2011, Tyack et al. 2011).

Moore and Barlow (2013) have noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. There are scientific caveats and limitations to the data used for this analysis, as well as oceanographic and species assemblage changes on the U.S. Pacific coast not thoroughly addressed. Interestingly, however, in the small portion of that area overlapping the Navy's SOCAL Range Complex, long-term residency by individual Cuvier's beaked whales and higher densities provide indications that the proposed decline noted elsewhere is not apparent where the Navy has been intensively training and testing with sonar and other systems for decades. While it is possible that a downward trend in beaked whales may have gone unnoticed at the range complex (due to a lack of survey precision) or that beaked whale densities may have been higher before the Navy began using sonar earlier in the 1900s, there are no data to suggest that beaked whale numbers have declined on the range where Navy sonar use has routinely occurred and as Moore and Barlow (2013) point out, it remains clear that the Navy range in Southern California continues to support high densities of beaked whales. Navy funding for monitoring of beaked whale and other marine species (involving visual survey, passive acoustic recording, and tagging studies) will continue in Southern California to develop additional data toward a clearer understanding of marine mammals inhabiting the Navy's range complexes.

To summarize, while the evidence covers most marine mammal taxonomic suborders, it is limited to a few species and only suggestive of the general viability of those species in intensively used Navy training and testing areas (Barlow et al. 2011; Calambokidis et al. 2009b; Falcone et al. 2009; Littnan 2011; Martin and Kok 2011; McCarthy et al. 2011; McSweeney et al. 2007; McSweeney et al. 2009; Moore and Barlow 2011; Tyack et al. 2011; Southall et al. 2012a). There is no direct evidence that routine Navy training and testing spanning decades has negatively impacted marine mammal populations at any Navy Range Complex. Although there have been a few strandings associated with use of sonar in other locations, as Ketten (2012) has recently summarized, "to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result of anthropogenic noise exposures, including sonar." Therefore, based on the best available science (McSweeney et al. 2007; Falcone et al. 2009; McSweeney et al. 2009; Littnan 2010; Barlow et al. 2011; Martin and Kok 2011; McCarthy et al. 2011; Moore and Barlow 2011; Tyack et al. 2011; Southall et al. 2012a; Manzano-Roth et al. (2013); Smultea and Jefferson 2014), including data developed in the series of 70 reports submitted to NMFS, the Navy believes that long-term consequences for individuals or populations are unlikely to result from military training and testing activities in the MITT Study Area.

Until an incident in March 2011, there were no known incidents or records of any explosives training activity involving injury to a marine mammal. At the SSTC at Coronado, California, on average per year there are approximately 415 in-water detonations occurring during an estimated 311 training events at that location. Despite the Navy's excellent decades-long track record, on 4 March 2011, an underwater demolition training event resulted in the known mortalities to four[11] long-beaked common dolphins. Range clearance procedures had been implemented, and there were no marine mammals in the area when the timed-fuse countdown to detonation began. Personnel moved back from the site, and just before the detonation was to occur, dolphins were observed moving into the clearance zone. Due to the danger to personnel, the Navy could not attempt to divert those animals, stop the timer, or disarm the explosive. As a result of this incident, in consultation with NMFS, the Navy modified the mitigation measures in existence when this incident occurred to prevent a reoccurrence (see Chapter 5 regarding Mine Neutralization Activities Using Diver-Placed Time-Delay Firing Devices). There are no underwater demolition training events or use of timed-fuses associated with underwater demolition proposed for the Study Area or as part of the Carrier Strike Group exercise or Sinking Exercise.

Although potential impacts to certain marine mammal species from the Proposed Action may include injury or mortality, impacts are not expected to decrease the overall fitness of any given population. In cases where potential impacts rise to the level that warrants mitigation, mitigation measures designed to reduce the potential impacts are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring).

3.4.5.3 Marine Mammal Protection Act Determinations

Pursuant to the MMPA, the Navy is seeking a 5-year Letter of Authorization from the NMFS for certain training and testing activities (the use of sonar and other acoustic sources, explosives, and vessels), as described under the Preferred Alternative (Alternative 1). The use of sonar and other active acoustic

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[11] Immediately after the detonation at the Silver Strand Training Complex (Coronado, California), Navy personnel found and recovered three dead long-beaked common dolphins; they reported the incident to the Navy chain of command, who informed NMFS, and Navy then transferred the recovered animals to the local stranding network for necropsy. Three days later, a long-beaked common dolphin was discovered at Oceanside, California (approximately 40 mi. [65 km] up the coast), and another was discovered 10 days after the training event at La Jolla, California (approximately 15 mi. [45 km] from the training site). Due to the species being one which commonly strands and the number of days and distance from the event, the association of this last stranded animals with the event is not certain (see Danil and St. Leger 2011).

sources and explosives may result in Level A harassment or Level B harassment of certain marine mammals. The use of vessels may result in Level A harassment, including mortality, of certain marine mammal species.

Refer to Section 3.4.4.1 (Impacts from Sonar and Other Active Acoustic Sources) for details on the estimated impacts from sonar and other active acoustic sources, Section 3.4.4.2 (Impacts from Explosives) for details on the estimated impacts from explosives, and Section 3.4.4.4.1 (Impacts from Vessel Strikes) for details on the estimated impacts from the use of vessels in the Study Area.

Military training and testing activities producing weapons firing, launch, and impact noise; vessel noise, aircraft noise; energy emissions; and impulses from swimmer defense airguns are not expected to result in Level A or Level B harassment of any marine mammals. Military training and testing activities using in-water devices, seafloor devices, fiber optic cables and guidance wires, decelerators/parachutes, non-explosive practice munitions, and other military expended materials are not expected to result in Level A or Level B harassment of any marine mammals. Secondary stressors (impacts to habitat or prey from explosives and byproducts, metals, chemicals, and transmission of disease and parasites) are also not expected to result in Level A or Level B harassment of any marine mammals.

3.4.5.4 Endangered Species Act Determinations

The NMFS administers the ESA for marine mammals in the Study Area. The guidelines followed to make a determination of no effect; may affect, not likely to adversely affect; or may affect, likely to adversely affect can be found in the *Endangered Species Act Consultation Handbook* (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998).

In accordance with ESA requirements, the Navy will undertake Section 7 consultation with NMFS for the proposed activities in the MITT Study Area under Alternative 1 as the preferred alternative. Table 3.4-27 provides the determinations made for each sub-stressor and ESA-listed marine mammal species pursuant to the ESA from the analysis presented in the sections previously. There is no ESA-designated critical habitat in the Study Area.

Table 3.4-27: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 1)

Activity		Species				
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Sperm Whale
Acoustic Stressors						
Sonar and Other Active Acoustic Sources	Training Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect
	Testing Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect
Explosives	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Swimmer Defense Airguns	Testing Activities	No Effect	No Effect	No Effect	No Effect	No Effect
Weapons Firing, Launch, and Impact Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Aircraft Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

Table 3.4-27: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 1) (continued)

Activity		Species				
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Sperm Whale
Vessel Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Energy Stressors						
Electromagnetic Devices	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Physical Disturbance and Strike Stressors						
Vessels	Training Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect
	Testing Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect
In-Water Devices	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Military Expended Materials	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

Table 3.4-27: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 1) (continued)

Activity		Species				
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Sperm Whale
Seafloor Devices	Training Activities	No Effect	No Effect	No Effect	No Effect	No Effect
	Testing Activities	No Effect	No Effect	No Effect	No Effect	No Effect
Entanglement Stressors						
Fiber Optic Cables and Guidance Wires	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Decelerators/ Parachutes	Training Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect
	Testing Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect
Ingestion Stressors						
Military Expended Materials from Munitions	Training Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect
	Testing Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect
Military Expended Materials other than Munitions	Training Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect
	Testing Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect

Table 3.4-27: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 1) (continued)

Activity		Species				
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Sperm Whale
Secondary Stressors						
Secondary Stressors	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

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