3.4 Marine Mammals

Supplemental Environmental Impact Statement/
Overseas Environmental Impact Statement
Mariana Islands Training and Testing

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3.4.1 Affected Environment

The purpose of this section is to supplement the analysis of impacts on marine mammals presented in the 2015 Mariana Islands Training and Testing (MITT) Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) with new information relevant to proposed changes in training and testing activities conducted at sea and on Farallon de Medinilla (FDM). Information presented in the 2015 MITT Final EIS/OEIS that remains valid is noted as such and referenced in the appropriate sections. Any new or updated information describing the affected environment and analysis of impacts on marine mammals associated with the Proposed Action is provided in this section. Comments received from the public during scoping related to marine mammals are addressed in Section 3.4.6 (Public Scoping Comments).

The complete analysis and summary of potential impacts of the Proposed Action on marine mammals are found in Section 3.4.2 (Environmental Consequences) and Section 3.4.3 (Summary of Potential Impacts on Marine Mammals). For additional information, also see the 2015 MITT Final EIS/OEIS, Section 3.4 (Marine Mammals) (U.S. Department of the Navy, 2015a).

3.4.1.1 General Background

Marine mammals are a diverse group of approximately 130 species. Most live predominantly in the marine habitat, although some species, such as seals, spend time in terrestrial habitats, and other species such as manatees and certain dolphins spend time in freshwater habitats (Rice, 1998; U.S. Department of the Navy, 2007). The exact number of formally recognized marine mammal species changes periodically with new scientific understanding or findings (Rice, 1998). For a list of current species classifications, see the formal list of *Marine Mammal Species and Subspecies* maintained online by the Society for Marine Mammalogy. In this document, the Navy follows the naming conventions presented by National Marine Fisheries Service (NMFS) in the applicable annual Stock Assessment Reports (SAR) for the Pacific and Alaska[1] regions covering the marine mammals present in the MITT Study Area (Carretta et al., 2017d; Carretta et al., 2018a; Muto et al., 2017b).

All marine mammals in the United States are protected under the Marine Mammal Protection Act (MMPA), and some species receive additional protection under the Endangered Species Act (ESA). The MMPA defines a marine mammal “stock” as “a group of marine mammals of the same species or smaller taxon in a common spatial arrangement that interbreed when mature” (16 United States Code [U.S.C.] section 1362; for further details, see Oleson et al. (2013). As provided by NMFS guidance, “for purposes of management under the MMPA a stock is recognized as being a management unit that identifies a demographically independent biological population.” (Carretta et al., 2017c; National Marine Fisheries Service, 2016b). However, in practice, recognized management stocks may fall short of this ideal for various reasons, including a lack of information, and, in some cases, may even include multiple distinct population segments in a management unit, such as with the Western North Pacific humpback whale stock (Bettridge et al., 2015).

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[1] Some stocks in the Pacific and the Mariana Islands, such as the Northeast Pacific stocks of sperm whales and fin whales, and the Western North Pacific Stock of humpback whales, which include individuals that may spend the summer season foraging in Alaska waters, are covered in the Alaska Stock Assessment Report.

The ESA provides for listing species, subspecies, or distinct population segments of species, all of which are referred to as "species" under the ESA. The *Interagency Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the ESA* defines a distinct population segment as, "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature" (61 Federal Register [FR] 4722, February 7, 1996). If a population meets the criteria to be identified as a distinct population segment, it is eligible for listing under the ESA as a separate species (National Marine Fisheries Service, 2016b).

Twenty-six cetacean marine mammal species are known to exist in the Study Area, including 7 mysticetes (baleen whales) and 19 odontocetes (dolphins and toothed whales) (U.S. Department of the Navy, 2005, 2018b). The species expected to be present in the Study Area are provided in Table 3.4-1 and listed alphabetically within the two suborder groupings. The information presented in this Supplemental EIS (SEIS)/OEIS incorporates data from the U.S. Pacific and the Alaska Marine Mammal Stock Assessments (Carretta et al., 2017d; Muto et al., 2017b), which cover some of those species present in the Study Area and incorporate the best available science, including monitoring data from Navy marine mammal research efforts. For those few species for which stock information exists in the region, relevant data are included in the species-specific Status and Management summaries provided subsequently in this section.

Table 3.4-1: Marine Mammal Occurrence within the Study Area

Common Name[1]	*Scientific Name*	*ESA Status*	*Occurrence in Study Area*		
			Mariana Islands	*Transit Corridor*	*Apra Harbor*
Mysticetes					
Blue whale	*Balaenoptera musculus*	Endangered	Seasonal	Seasonal	-
Bryde's whale	*Balaenoptera edeni*	n/a	Regular	Regular	-
Fin whale	*Balaenoptera physalus*	Endangered	Rare	Rare	-
Humpback whale	*Megaptera novaeangliae*	Endangered	Seasonal	Seasonal	-
Minke whale	*Balaenoptera acutorostrata*	n/a	Seasonal	Seasonal	-
Omura's whale	*Balaenoptera omurai*	n/a	Rare	Rare	-
Sei whale	*Balaenoptera borealis*	Endangered	Seasonal	Seasonal	-
Odontocetes					
Blainville's beaked whale	*Mesoplodon densirostris*	n/a	Regular	Regular	-
Common bottlenose dolphin	*Tursiops truncatus*	n/a	Regular	Regular	-
Cuvier's beaked whale	*Ziphius cavirostris*	n/a	Regular	Regular	-
Dwarf sperm whale	*Kogia sima*	n/a	Regular	Regular	-

Table 3.4-1: Marine Mammal Occurrence within the Study Area (continued)

Common Name[1]	***Scientific Name***	***ESA Status***	***Occurrence in Study Area***		
			Mariana Islands	***Transit Corridor***	***Apra Harbor***
Odontocetes					
False killer whale	*Pseudorca crassidens*	n/a	Regular	Regular	-
Fraser's dolphin	*Lagenodelphis hosei*	n/a	Regular	Regular	-
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	n/a	Regular	Regular	-
Killer whale	*Orcinus orca*	n/a	Regular	Regular	-
Longman's beaked whale	*Indopacetus pacificus*	n/a	Regular	Regular	-
Melon-headed whale	*Peponocephala electra*	n/a	Regular	Regular	-
Pantropical spotted dolphin	*Stenella attenuata*	n/a	Regular	Regular	-
Pygmy killer whale	*Feresa attenuata*	n/a	Regular	Regular	-
Pygmy sperm whale	*Kogia breviceps*	n/a	Regular	Regular	-
Risso's dolphin	*Grampus griseus*	n/a	Regular	Regular	-
Rough-toothed dolphin	*Steno bredanensis*	n/a	Regular	Regular	-
Short-finned pilot whale	*Globicephala macrorhynchus*	n/a	Regular	Regular	-
Sperm whale	*Physeter macrocephalus*	Endangered	Regular	Regular	-
Spinner dolphin	*Stenella longirostris*	n/a	Regular	Regular	-
Striped dolphin	*Stenella coeruleoalba*	n/a	Regular	Regular	-

[1] If available for the species, information on stocks is included in the species-specific Status and Management summaries.

Notes: n/a = status is not applicable for those species that are not listed under ESA; 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; Seasonal = species is only seasonally present in the Study Area. Additional details regarding presence in the Study Area are provided in the species-specific subsections.

3.4.1.2 Species Unlikely to Be Present in the Study Area

Consistent with the analysis provided in the 2015 MITT Final EIS/OEIS, the species carried forward for analysis in this SEIS/OEIS are those likely to be found in the Study Area based on the most recent sighting, survey, and habitat modeling data available. The analysis does 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*), northern elephant seal (*Mirounga angustirostris*), and dugong (*Dugong dugon*). Details regarding the reasons for these exclusions are explained in detail in the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015a).

3.4.1.3 Group Size

Many species of marine mammals, particularly odontocetes, are highly social animals that spend much of their lives living in groups called "pods." The size and structures of these groups are dynamic and depending on the species, can range from several to several thousand individuals. Similarly, aggregations of mysticete whales may form during particular breeding or foraging seasons, although they do not persist through time as a social unit. Marine mammals that live or travel in groups are more likely to be detected by observers, and group size characteristics are incorporated into the many density and abundance calculations. Group size characteristics are also incorporated into acoustic effects modeling to represent a more realistic patchy distribution for a given density. The behavior of aggregating into groups is also important for the purposes of mitigation and monitoring since animals that occur in larger groups have an increased probability of being detected. A comprehensive and systematic review of relevant literature and data was conducted for available published and unpublished literature, including journals, books, technical reports, cruise reports, and raw data from cruises, theses, and dissertations. The results of this review were compiled into a Technical Report, which includes tables of group size information by species along with relevant citations.

3.4.1.4 Habitat Use

Many factors influence the distribution of marine mammals in the Study Area, primarily patterns of major ocean currents, bottom relief, and water temperature, which, in turn, affect prey distribution and productivity. The continuous movement of water from the ocean bottom to the surface creates a nutrient-rich, highly productive environment for marine mammal prey in upwelling zones (Jefferson et al., 2015); the equatorial upwelling in the western Pacific is one such area (Di Lorenzo et al., 2010; Helber & Weisberg, 2001). While most baleen whales (such as humpback whales) are migratory, some species such as Bryde’s whales and Omura’s whales are thought to be present within the Study Area year round. Many of the toothed whales do not migrate in the strictest sense, but some do undergo seasonal shifts in distribution both within and outside of the Study Area.

3.4.1.5 Dive Behavior

All marine mammals, with the exception of polar bears, spend part of their lives underwater while traveling or feeding. 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. The diving behavior of a particular species or individual has implications for the ability to visually detect them for mitigation and monitoring. In addition, their relative distribution through the water column based on diving behavior is an important consideration when conducting acoustic effects modeling. Information and data on diving behavior for each species of marine mammal were compiled and summarized in a technical report (U.S. Department of the Navy, 2018a) that provides the detailed summary of time at depth.

3.4.1.6 Hearing and Vocalization

The typical terrestrial mammalian ear (which is ancestral to that of marine mammals) consists of an outer ear that collects and transfers sound to the tympanic membrane and then to the middle ear (Fay & Popper, 1994; Rosowski, 1994). The middle ear contains ossicles that amplify and transfer acoustic energy to the sensory cells (called hair cells) in the cochlea, which transforms acoustic energy into electrical neural impulses that are transferred by the auditory nerve to high levels in the brain (Møller, 2013). All marine mammals display some degree of modification to the terrestrial ear; however, there are differences in the hearing mechanisms of marine mammals with an amphibious ear versus those with a fully aquatic ear (Wartzok & Ketten, 1999). Marine mammals with an amphibious ear include the marine carnivores: pinnipeds, sea otters, and polar bears (Ghoul & Reichmuth, 2014; Owen & Bowles, 2011; Reichmuth et al., 2013). Outer ear adaptations in this group include external pinnae (ears) that are reduced or absent, and in the pinnipeds, cavernous tissue, muscle, and cartilaginous valves seal off water from entering the auditory canal when submerged (Wartzok & Ketten, 1999). Marine mammals with the fully aquatic ear (cetaceans and sirenians) use bone and fat channels in the head to conduct sound to the ear; while the auditory canal still exists it is narrow and sealed with wax and debris (Ketten, 1998).

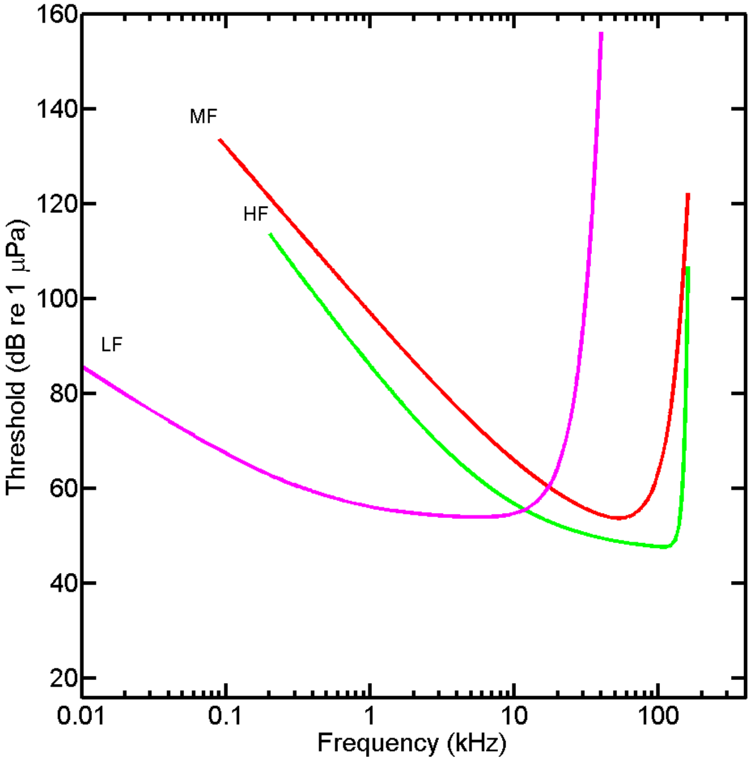
The most accurate means of determining the hearing capabilities of marine mammal species are direct measures that assess the sensitivity of the auditory system (Nachtigall et al., 2000; Supin et al., 2001). Studies using these methods produce audiograms — plots describing hearing threshold (the quietest sound a listener can hear) as a function of frequency. Marine mammal audiograms, like those of terrestrial mammals, typically have a "U-shape," with a frequency region of best hearing sensitivity and a progressive decrease in sensitivity outside of the range of best hearing (Fay, 1988; Mooney et al., 2012; Nedwell et al., 2004; Reichmuth et al., 2013). The "gold standard" for producing audiograms is the use of behavioral (psychophysical) methods, where marine mammals are trained to respond to acoustic stimuli (Nachtigall et al., 2000). For species that are untrained for behavioral psychophysical procedures, those that are difficult to house under human care, or in stranding rehabilitation and temporary capture contexts, auditory evoked potential methods are increasingly used to measure hearing sensitivity (e.g., Castellote et al., 2014; Finneran et al., 2009; Montie et al., 2011; Mulsow et al., 2011; Nachtigall et al., 2007; Nachtigall et al., 2008; Supin et al., 2001).

These auditory evoked potential methods, which measure electrical potentials generated by the auditory system in response to sound and do not require the extensive training of psychophysical methods, can provide an efficient estimate of behaviorally measured sensitivity (Finneran & Houser, 2006; Schlundt et al., 2007; Yuen et al., 2005). The thresholds provided by auditory evoked potential methods are, however, typically elevated above behaviorally measured thresholds, and auditory evoked potential methods are not appropriate for estimating hearing sensitivity at frequencies much lower than the region of best hearing sensitivity (Finneran, 2015; Finneran et al., 2016). For marine mammal species for which access is limited and therefore psychophysical or auditory evoked potential testing is impractical (e.g., mysticete whales and rare species), some aspects of hearing can be estimated from anatomical structures, frequency content of vocalizations, and extrapolations from related species.

Direct measurements of hearing sensitivity exist for approximately 25 of the nearly 130 species of marine mammals. Table 3.4-2 summarizes hearing capabilities for marine mammal species in the Study Area. For this analysis, marine mammals are arranged into the following functional hearing groups based on their generalized hearing sensitivities: high-frequency (HF) cetaceans (HF group: porpoises, Kogia whales), mid-frequency (MF) cetaceans (MF group: delphinids, beaked whales, sperm whales), and low-frequency (LF) cetaceans (LF group: mysticetes). Note that the designations of high-, mid-, and low-frequency cetaceans are based on relative differences of sensitivity between groups, as opposed to conventions used to describe active sonar systems. For Phase III analyses, a single representative composite audiogram (Figure 3.4-1) was created for each functional hearing group using audiograms from published literature. For discussion of all marine mammal functional hearing groups and their derivation see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a). The mid-frequency cetacean composite audiogram is consistent with recently published behavioral audiograms of killer whales (Branstetter et al., 2017a).

Table 3.4-2: Species within Marine Mammal Hearing Groups Likely Found in the Study Area

Hearing Group	*Species within the Study Area*
High-frequency cetaceans	Dwarf sperm whale
	Pygmy sperm whale
Mid-frequency cetaceans	Blainville's beaked whale
	Common bottlenose dolphin
	Cuvier's beaked whale
	False killer whale
	Fraser's dolphin
	Ginkgo-toothed beaked whale
	Killer whale
	Longman's beaked whale
	Melon-headed whale
	Northern right whale dolphin
	Pantropical spotted dolphin
	Pygmy killer whale
	Risso's dolphin
	Rough-toothed dolphin
	Short-finned pilot whale
	Sperm whale
	Spinner dolphin
	Striped dolphin
Low-frequency cetaceans	Blue whale
	Bryde's whale
	Fin whale
	Humpback whale
	Minke whale
	Omura's whale
	Sei whale



Source: (U.S. Department of the Navy, 2017a)

Notes: For hearing in the water; LF = low-frequency, MF = mid-frequency, HF = high-frequency

Figure 3.4-1: Composite Audiograms for Hearing Groups Likely Found in the Study Area

Similar to the diversity of hearing capabilities among species, the wide variety of acoustic signals used in marine mammal communication (including biosonar or echolocation) is reflective of the diverse ecological characteristics of cetacean species (see Avens, 2003; Richardson et al., 1995b). This makes a succinct summary difficult (see Richardson et al., 1995b; Wartzok & Ketten, 1999 for thorough reviews); however, a division can be drawn between lower frequency communication signals that are used by marine mammals in general, and the specific, high-frequency biosonar signals that are used by odontocetes to sense their environment.

Non-biosonar communication signals span a wide frequency range, primarily having energy up into the tens of kilohertz (kHz) range. Of particular note are the very low-frequency calls of mysticete whales that range from tens of hertz (Hz) to several kilohertz, and have source levels of 150–200 decibels referenced to 1 micropascal (dB re 1 µPa) (Cummings & Thompson, 1971; Edds-Walton, 1997; Širović et al., 2007; Stimpert et al., 2007; Wartzok & Ketten, 1999). These calls most likely serve social functions such as mate attraction, but may serve an orientation function as well (Green, 1994; Green et al., 1994; Richardson et al., 1995b). Humpback whales are a notable exception within the mysticetes, with some calls exceeding 10 kHz (Zoidis et al., 2008).

Odontocete cetaceans use underwater communicative signals that, while not as low in frequency as those of many mysticetes, likely serve similar functions. The acoustic characteristics of these signals are quite diverse among species, but can be generally classified as having dominant energy at frequencies below 20 kHz (Richardson et al., 1995b; Wartzok & Ketten, 1999).

Odontocete cetaceans generate short-duration (500–200 µs), specialized clicks used in biosonar with peak frequencies between 10 and 200 kHz to detect, localize, and characterize underwater objects such as prey (Au, 1993; Wartzok & Ketten, 1999). These clicks are often more intense than other communicative signals, with reported source levels as high as 229 dB re 1 µPa peak-to-peak (Au et al., 1974). The echolocation clicks of high-frequency cetaceans are narrower in bandwidth (i.e., the difference between the upper and lower frequencies in a sound) and higher in frequency than those of mid-frequency cetaceans (Madsen et al., 2005; Villadsgaard et al., 2007).

In general, frequency ranges of vocalization lie within the audible frequency range for an animal (i.e., animals vocalize within their audible frequency range); however, auditory frequency range and vocalization frequencies do not perfectly align. The frequency range of vocalization in a species can therefore be used to infer some characteristics of their auditory system; however, caution must be taken when considering vocalization frequencies alone in predicting the hearing capabilities of species for which no data exist (i.e., mysticetes). It is important to note that aspects of vocalization and hearing sensitivity are subject to evolutionary pressures that are not solely related to detecting communication signals. For example, hearing plays an important role in detecting threats (e.g., Deecke et al., 2002), and high-frequency hearing is advantageous to animals with small heads in that it facilitates sound localization based on differences in sound levels at each ear (Heffner & Heffner, 1982). This may be partially responsible for the difference in best hearing thresholds and dominant vocalization frequencies in some species of marine mammals (e.g., Steller sea lions) (Mulsow & Reichmuth, 2010).

3.4.1.7 General Threats

Marine mammal populations can be influenced by various natural factors as well as human activities. There can be direct effects from disease, hunting, and whale watching, or indirect effects such as through reduced prey availability or lowered reproductive success of individuals. Research presented in Twiss and Reeves (1999) and National Marine Fisheries Service (2011a, 2011b, 2011c, 2011d) provides a general discussion of marine mammal conservation and the threats they face. As detailed in National Marine Fisheries Service (2011e), investigations of stranded marine mammals are undertaken to monitor threats to marine mammals (Simeone et al., 2015). Investigations into the cause of death for stranded animals can also provide indications of the general threats to marine mammals in a given location (Bradford & Forney, 2017; Carretta et al., 2017b; Helker et al., 2017). The causes for strandings include infectious disease, parasite infestation, climate change reducing prey availability and leading to starvation, pollution exposure, trauma (e.g., injuries from ship strikes or fishery entanglements), sound (human-generated or natural), harmful algal blooms and associated biotoxins, tectonic events such as underwater earthquakes, and ingestion of or interaction with marine debris (for more information see NMFS Marine Mammal Stranding Response Fact Sheet (National Marine Fisheries Service, 2016d). Since 1963, Guam Department of Agriculture Division of Aquatic and Wildlife Resources has conducted aerial surveys twice every month (weather permitting) of the coastal margin around Guam at a distance of approximately 200–300 meters (m) offshore of the outer reef margin (Martin et al., 2016). Therefore, the Navy assumes any animals stranded on Guam are likely to have been identified; see also Mobley (2007). For a general discussion of strandings and their causes as well as strandings in association with U.S. Navy activity, see the technical report titled *Strandings Associated with U.S. Navy Activity* (U.S. Department of the Navy, 2017c).

3.4.1.7.1 Water Quality

Chemical pollution and impacts on ocean water quality are of great concern, although the effects on marine mammals are just starting to be understood (Bachman et al., 2014; Bachman et al., 2015;

Desforges et al., 2016; Foltz et al., 2014; Godard-Codding et al., 2011; Hansen et al., 2015; Jepson & Law, 2016; Law, 2014; Peterson et al., 2014; Peterson et al., 2015; Ylitalo et al., 2005; Ylitalo et al., 2009). Oil and other chemical spills are a specific type of ocean contamination that can have damaging effects on some marine mammal species directly through exposure to oil or chemicals and indirectly due to pollutants' impacts on prey and habitat quality (Engelhardt, 1983; Marine Mammal Commission, 2010; Matkin et al., 2008).

On a broader scale ocean contamination resulting from chemical pollutants inadvertently introduced into the environment by industrial, urban, and agricultural use is also a concern for marine mammal conservation and has been the subject of numerous studies (Desforges et al., 2016; Fair et al., 2010; Krahn et al., 2007; Krahn et al., 2009; Moon et al., 2010; Ocean Alliance, 2010). For example, the chemical components of pesticides used on land flow as runoff into the marine environment, which can accumulate in the bodies of marine mammals, and be transferred to nursing young through the mother's milk (Fair et al., 2010). The presence of these chemicals in marine mammals has been assumed to put those animals at greater risk for adverse health effects and potential impact on their reproductive success given toxicology studies and results from laboratory animals (Fair et al., 2010; Godard-Codding et al., 2011; Krahn et al., 2007; Krahn et al., 2009; Peterson et al., 2014; Peterson et al., 2015). Desforges et al. (2016) have suggested that exposure to chemical pollutants may act in an additive or synergistic manner with other stressors resulting in significant population level consequences. Although the general trend has been a decrease in chemical pollutants in the environment following their regulation, chemical pollutants remain important given their potential to impact marine mammals and marine life in general (Bonito et al., 2016; Jepson & Law, 2016; Law, 2014).

3.4.1.7.2 Commercial Industries

Human impacts on marine mammals through fisheries interactions have received much attention in recent decades, and include bycatch (accidental or incidental catch), gear entanglement, and indirect effects from takes of prey species; noise pollution; marine debris (ingestion and entanglement); hunting (both commercial and native practices); vessel strikes; entrainment into power plant water intakes; increased ocean acidification; and general habitat deterioration or destruction.

3.4.1.7.3 Bycatch

Fishery bycatch is likely the most impactful threat to marine mammal individuals and populations and may account for the deaths of more marine mammals than any other cause (Bradford & Forney, 2017; Carretta et al., 2016b; Carretta et al., 2017b; Geijer & Read, 2013; Hamer et al., 2010; Helker et al., 2017; Lent & Squires, 2017; National Marine Fisheries Service, 2016c; Northridge, 2009; Read, 2008; Song, 2017). In 1994, the MMPA was amended to formally address bycatch in the United States. The amendment required the development of a take reduction plan when bycatch exceeds a level considered sustainable and lead to marine mammal population decline. In addition, NMFS develops and implements take reduction plans that help recover and prevent the depletion of strategic stocks of marine mammals that interact with certain fisheries.

At least in part as a result of the amendment, estimates of bycatch in the Pacific by U.S. fisheries declined by a total of 96 percent from 1994 to 2006 (Geijer & Read, 2013). Information on bycatch associated with non-U.S. fishery activities is generally not available in the Study Area. It has been argued that the bycatch of marine mammals by Japan and South Korea is more like an unregulated commercial hunt than an incidental or illegal fishery given the products from bycatch whales can be sold openly on commercial markets in both countries (Baker et al., 2006b; Lukoschek et al., 2009). For example, in 2008 the reported bycatch in Japan and South Korea totaled 214 minke whales (Lukoschek et al., 2009) and in nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that 230 products contained minke whale meat in addition to that of other species (Baker et al., 2006b). A total of 717 cetacean bycatches involving South Korean fish vessels in the East Sea that involved 10 species were reported in a two-year period between 2013 and 2014 (Song, 2017).

3.4.1.7.4 Other Fishery Interactions

Fishery interactions other than bycatch include entanglement in abandoned or partial nets, fishing line, hooks, and the ropes and lines connected to fishing gear (Bradford & Lyman, 2015; Bradford & Forney, 2016, 2017; Carretta, 2013; Carretta et al., 2014; Carretta et al., 2016b; Carretta et al., 2017b; Helker et al., 2015; Helker et al., 2017; National Oceanic and Atmospheric Administration, 2017; Richardson et al., 2016; Saez et al., 2013). The National Oceanic and Atmospheric Administration Marine Debris Program (2014b) reports that abandoned, lost, or otherwise discarded fishing gear constitutes the vast majority of mysticete entanglements. For the identified sources of entanglement, none included Navy-expended materials. Identified species entangled in the Pacific in 2015 and 2016 included humpback, gray, blue, fin and killer whales with a total of 133 entanglements in the two-year period (National Oceanic and Atmospheric Administration, 2017).

In waters off Alaska where humpback whales from the Study Area may forage in the summer season, passive acoustic monitoring efforts since 2009 have documented the routine use of non-military explosives at sea (Baumann-Pickering et al., 2013; Rice et al., 2015). Based on the acoustic spectral properties of the recorded sounds and their correspondence with known fishing seasons or activity, the source of these explosions has been linked to the use of explosive marine mammal deterrents, which as a group are commonly known as “seal bombs” (Baumann-Pickering et al., 2013). Seal bombs are intended to be used by commercial fishers to deter marine mammals, particularly pinnipeds, from preying upon their catch and to prevent marine mammals from interacting and potentially becoming entangled with fishing gear (National Marine Fisheries Service, 2015c). The prevalent and continued use of seal bombs in Alaska seems to indicate that, while a potential threat, their use has had no significant effect on populations of marine mammals given that it is likely at least some individuals, if not larger groups of marine mammals, have been repeatedly exposed to this explosive stressor.

3.4.1.7.5 Noise

In some locations, especially where urban or industrial activities or commercial shipping is intense, anthropogenic noise can be a potential habitat-level stressor (Dunlop, 2016; Dyndo et al., 2015; Erbe et al., 2014; Frisk, 2012; Gedamke et al., 2016; Hermannsen et al., 2014; Li et al., 2015; McKenna et al., 2012; Melcón et al., 2012; Miksis-Olds & Nichols, 2015; Nowacek et al., 2015; Pine et al., 2016; Williams et al., 2014b). 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 cause physiological stress (Courbis & Timmel, 2008; Erbe, 2002; Erbe et al., 2016; Hildebrand, 2009; Rolland et al., 2012; Tyack et al., 2011; Tyne et al., 2017; Williams et al., 2013). 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 (Erbe et al., 2014; Erbe et al., 2016; National Research Council, 2003, 2005; Nowacek et al., 2007a; Southall et al., 2009; Tyack, 2009; Würsig & Richardson, 2009). Anthropogenic noise is generated from a variety of sources including commercial shipping, oil and gas exploration and production activities, commercial and recreational fishing (including fish-finding sonar, fathometers, and acoustic deterrent and harassment devices), foreign navies, recreational boating and whale watching activities, offshore power generation, and research (including sound from air guns, sonar, and telemetry).

Vessel noise in particular is a major contributor to noise in the ocean (Southall et al., 2018). Commercial shipping's contribution to ambient noise in the ocean increased by as much as 12 decibels (dB) between approximately the 1960s and 2005 (Hildebrand, 2009; McDonald et al., 2008). Frisk (2012) confirmed the trend and reported that between 1950 and 2007 ocean noise in the 25–50 Hz frequency range has increased 3.3 dB per decade, resulting in a cumulative increase of approximately 19 dB over a baseline of 52 dB. The increase in noise is associated with an increase in commercial shipping, which correlates with global economic growth (Frisk, 2012). Subsequently, Miksis-Olds and Nichols (2015) have demonstrated that the trends for low-frequency ocean sound levels no longer show a uniform increase across the globe.

Although Guam and the Mariana Islands lack a major port, many thousands of trans-Pacific shipments to and from Asia occur as part of the global shipping transportation network and pass in proximity to the Mariana Islands and throughout the Study Area (Kaluza et al., 2010). Redfern et al. (2017) found that shipping channels leading to and from the ports of Los Angeles and Long Beach may have degraded the habitat for blue, fin, and humpback whales due to the loss of communication space where important habitat for these species overlaps with elevated noise from commercial vessel traffic, and similar impacts are also likely in the Study Area on great circle routes and other shortest point-to-point shipping routes.

In many areas of the world, including the Study Area, oil and gas seismic exploration in the ocean is undertaken using a group of air guns towed behind large research vessels. The airguns convert high pressure air into very strong shock wave impulses that are designed to return information off the various buried layers of sediment under the seafloor. Seismic exploration surveys last many days and cover vast overlapping swaths of the ocean area being explored. Most of the impulse energy produced by these airguns is heard as low-frequency sound, which can travel long distances and has the potential to impact marine mammals. NMFS routinely issues permits for the taking of marine mammals associated with these commercial activities.

3.4.1.7.6 Hunting

Commercial 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 & Reeves, 1999). With the enactment of the MMPA and the 1946 International Convention for the Regulation of Whaling, hunting-related mortality has decreased over the last 40 years. Unregulated harvests are still considered as direct threats. However, since passage of the MMPA, there have been relatively few serious calls for culls of marine mammals in the United States compared to other countries, including Canada (Roman et al., 2013). Review of uncovered Union of Soviet Socialist Republics catch records in the North Pacific Ocean indicate extensive illegal whaling activity between 1948 and 1979, with a harvest totaling 195,783 whales. Of these, only 169,638 were reported by the Union of Soviet Socialist Republics to the International Whaling Commission (Ilyashenko et al., 2013; Ilyashenko et al., 2014; Ilyashenko & Chapham, 2014; Ilyashenko et al., 2015).

3.4.1.7.7 Vessel Strike

Ship strikes are also a growing issue for most marine mammals, especially for large whales as populations recover from widespread commercial whaling. Some of the largest ports in the world are located to the west of the Study Area, and a substantial portion of the world's commercial vessel traffic from Asia and Japan transits through the Study Area heading south to ports of call along the coast of eastern Australia and to New Zealand, in addition to goods shipped into the Mariana Islands.

Since 1995, the U.S. Navy and U.S. Coast Guard have reported all known or suspected vessel collisions with whales to NMFS. There are no known collisions between Navy vessels and whales in the MITT Study Area associated with any of the proposed training or testing activities. The assumed under-reporting of whale collisions by vessels other than U.S. Navy or U.S. Coast Guard makes any comparison of data involving vessel strikes between Navy vessels and other vessels heavily biased. This under-reporting is recognized by NMFS; for example, in the Technical Memorandum providing the analysis of the impacts from vessel collisions with whales in Hawaii (Bradford & Lyman, 2015), NMFS takes into account unreported vessel strikes by civilian vessels.

3.4.1.7.8 Disease and Parasites

As with humans, marine mammals, especially the young, old, and weak, are susceptible to disease. For example, the first case of morbillivirus (a virus related to measles in humans) in the central Pacific was documented for a stranded juvenile male Longman's beaked whale discovered in 2010 in Hawaii (West et al., 2012; West et al., 2015) and subsequently in 2011 *brucella* (a bacterial pathogen) and *morbillivirus* were discovered in a sperm whale that stranded on Oahu (West et al., 2015); both these species are present in the Study Area. Occasionally disease epidemics can also injure or kill a large percentage of a marine mammal population (Keck et al., 2010; Paniz-Mondolfi & Sander-Hoffmann, 2009; Simeone et al., 2015). Recent review of odontocetes stranded along the California coast from 2000 to 2015 found evidence for morbilliviral infection in 9 of the 212 animals examined, therefore indicating this disease may be a contributor to mortality in cetaceans stranding along the California coast (Serrano et al., 2017).

Mass die-offs of some marine mammal species have been linked to toxic algal blooms, which occur as larger organisms consume multiple prey containing those toxins and thereby accumulating fatal doses. A comprehensive study that sampled over 900 marine mammals across 13 species, including several mysticetes, odontocetes, pinnipeds, and mustelids in Alaska, found detectable concentrations of domoic acid in all 13 species and saxitoxin, a toxin absorbed from ingesting dinoflagellates, in 10 of the 13 species (Lefebvre et al., 2016). Algal toxins may have contributed to the stranding and mortality of 30 whales found around the islands in the western Gulf of Alaska and the southern shoreline of the Alaska Peninsula starting in May 2015 (National Oceanic and Atmospheric Administration, 2016; Rosen, 2015; Savage et al., 2017; Summers, 2017). These findings from studies in Alaska are relevant to the Study Area given that the fin and humpback whales from the Mariana Islands migrate to Alaska waters in the summer to feed.

Additionally, all marine mammals have parasites that, under normal circumstances, probably do little overall harm, but under certain conditions, can cause serious health problems or even death (Bull et al., 2006; Fauquier et al., 2009; Jepson et al., 2005). Parasitic toxoplasmosis from feral cats (introduced into the ocean from urban runoff) has been found in two stranded spinner dolphins and eight monk seals in Hawaii (Rogers, 2016; West, 2018). In 2011, a Cuvier's beaked whale stranded at Saipan, when necropsied, it was found to have abnormalities and a level of parasitism that resulted in "the worst example of kidneys" the stranding coordinator said he had ever seen (Saipan Tribune, 2011).

3.4.1.7.9 Climate Change

The global climate is warming and is having impacts on some populations of marine mammals (National Marine Fisheries Service, 2015e; National Oceanic and Atmospheric Administration, 2018a; Salvadeo et al., 2010; Shirasago-Germán et al., 2015; Simmonds & Eliott, 2009). Climate change can affect marine mammal species directly by causing them to shift their distribution to match physiological tolerance under changing environmental conditions (Doney et al., 2012; Silber et al., 2017), which may or may not result in net habitat loss (some can experience habitat gains). Climate change can also affect marine mammals indirectly via impacts on prey, changes in prey distributions and locations, and changes in water temperature (Giorli & Au, 2017). Changes in prey can impact marine mammal foraging success, which in turn affects reproductive success and survival. Researchers in July 2016 shifted the location of blue, fin, and humpback whale satellite tagging efforts from Southern California to Central California, following sightings of thin and apparently unwell whales. The whales' conditions were thought to be the result of a change in the distribution of their prey away from traditional foraging areas. (Oregon State University, 2017) In Central California waters, the researchers identified good numbers of blue, fin, and humpback whales in better condition and indicative of a good feeding area that was likely to be sustained that season (Oregon State University, 2017).

Harmful algal blooms may become more prevalent in warmer ocean waters with increased salinity levels such that blooms will begin earlier, last longer, and cover a larger geographical range (Edwards, 2013; Moore, 2008). Warming ocean waters have been linked to the spread of harmful algal blooms into the North Pacific where waters had previously been too cold for most of these algae to thrive. Most of the mysticetes found in the Study Area spend part of the year in the North Pacific. The spread of the algae and associated blooms has led to disease in marine mammals in locations where algae-caused diseases had not been previously known (Lefebvre et al., 2016).

Climate change may indirectly influence marine mammals through changes in human behavior, such as increased shipping and oil and gas extraction, which benefit from sea ice loss (Alter et al., 2010). Ultimately impacts from global climate change may result in an intensification of current and on-going threats to marine mammals (Edwards, 2013).

Marine mammals are influenced by climate-related phenomena, such as typhoons and shifts in extreme weather patterns such as the 2015–2016 El Niño in the ocean off the U.S. West Coast. 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 (Bradshaw et al., 2006; Marsh, 1989; Rosel & Watts, 2008; Zellar et al., 2017), or other oceanographic conditions. Indirect impacts of climate change may include altered water chemistry in estuaries (low dissolved oxygen or increased nutrient loading) causing massive fish kills (Burkholder et al., 2004), which changes prey distribution and availability for cetaceans (Stevens et al., 2006). Human responses to extreme weather events may indirectly affect behavior and reproductive rates of marine mammals. For example, Miller et al. (2010) reported an increase in reproductive rates in bottlenose dolphins after Hurricane Katrina in the Mississippi Sound, presumably resulting from an increase in fish abundance due to a reduction in fisheries landings, a decrease in recreational and commercial boat activities (National Marine Fisheries Service, 2007b), and an increase in the number of reproductively active females available during the breeding seasons following the storm. Smith et al. (2013a) supplemented the findings from this study and documented a marked increase in foraging activity in newly identified foraging areas that were observed during the two-year study period after the storm.

Habitat deterioration and loss is a major factor for almost all coastal and inshore species of marine mammals and may include such factors as depleting a habitat's prey base and the complete loss of habitat (Ayres et al., 2012; Kemp, 1996; Pine et al., 2016; Rolland et al., 2012; Smith et al., 2009; Veirs et al., 2015; Williams et al., 2014a). Many researchers predict that if oceanic temperatures continue to rise with an associated effect on marine habitat and prey availability, then either changes in foraging or life history strategies, including poleward shifts in many marine mammal species distributions, should be anticipated (Alter et al., 2010; Fleming et al., 2016; Ramp et al., 2015; Salvadeo et al., 2015; Sydeman & Allen, 1999). Poloczanska et al. (2016) analyzed climate change impact data that integrates multiple climate-influenced changes in ocean conditions (e.g., temperature, acidification, dissolved oxygen, and rainfall) to assess anticipated changes to a number of key ocean fauna across representative areas. Their results predict a northward expansion in the distribution of zooplankton, fish, and squid, all of which are prey for many marine mammal species.

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

3.4.1.7.10 Marine Debris

The majority of marine debris in the ocean comes from land-based sources (Jambeck et al., 2015; Thiel et al., 2018). Without improved waste management and infrastructure in undeveloped coastal countries worldwide, the cumulative quantity of plastic waste available to enter the ocean from land is predicted to increase by an order of magnitude by 2025 (Jambeck et al., 2015). Marine debris is a global threat to marine mammals (National Oceanic and Atmospheric Administration Marine Debris Program, 2014a; Puig-Lozano et al., 2018). A literature review by Baulch and Perry (2014) found that 56 percent of cetacean species are documented as having ingested marine debris and that it can be a significant source of injury and mortality. A Cuvier's beaked whale that stranded at Saipan in 2011 was found to have an approximate 1-inch-diameter circular piece of plastic in its stomach (Saipan Tribune, 2011). Attributing cause of death to marine debris ingestion is difficult (Laist, 1997), but ingestion of plastic bags and Styrofoam has been identified as the cause of injury or death of minke whales (De Pierrepont et al., 2005) and deep-diving odontocetes, including beaked whales (Baulch & Perry, 2014), pygmy sperm whales (Sadove & Morreale, 1989; Stamper et al., 2006; Tarpley & Marwitz, 1993), and sperm whales (Jacobsen et al., 2010; Sadove & Morreale, 1989; Unger et al., 2016).

Without improved waste management and infrastructure in undeveloped coastal countries worldwide, the cumulative quantity of plastic waste available to enter the ocean from land is predicted to increase by an order of magnitude by 2025 (Jambeck et al., 2015). There have been not marine debris surveys in the Mariana Islands, so information from the Hawaiian Islands may be relevant. Since 1996, NOAA has removed 848 metric tons of derelict fishing nets and debris from the Northwest Hawaiian Islands and has estimated that an additional 52 tons of debris collects on the shallow coral reefs and shores there every year (National Oceanic and Atmospheric Administration Fisheries, 2018). From April 2013 to April 2016 in the waters around Lanai and channels between Lanai, Maui, and Kahoolawe, surveys were conducted to quantify the presence of marine mammals and floating marine debris (Currie et al., 2017). The surveys encountered, collected, and categorized 1,027 pieces of marine debris. Items categorized as "plastic" were the predominant type of debris encountered, accounting for 86 percent of total debris and consisting mainly of plastic bottles, tubs, baskets, foamed polystyrene disposable plates, cups, fragments, plastic bags, and other soft plastic films. A smaller portion of the plastic debris (13 percent; 11 percent of the total debris) was fishing-related and included items such as buoys, netting, rope, and fishing lines; milled lumber and rubber accounted for 10 percent of debris, with the remaining 4 percent attributed to metal, glass, and clothing/fabric. Similar findings have been documented for other locations in the Pacific region (Choy & Drazen, 2013; Horton et al., 2017; Smith, 2012).

Although there are no similar records for the Study Area, for some of the same cetacean species in Hawaii between 2007 and 2012, there were 48 humpback whales, a sperm whale, a bottlenose dolphin, 3 spinner dolphins, and a pantropical spotted dolphin found entangled in marine debris (Bradford & Lyman, 2015). One humpback whale was known to be injured, and it is believed that interaction with debris led to the mortality of a second humpback whale and a spinner dolphin (Bradford & Lyman, 2015). Marine mammals migrating from the Mariana Islands to Alaska also encounter threats outside the Study Area. In Alaska from 2011 through 2015, records of approximately 3,700 human-marine mammal interactions were reviewed by NMFS and determined to have resulted in 440 entanglement/entrapment-related marine mammal serious injury or mortality to various species (Helker et al., 2017).

An estimated 75 percent or more of marine debris consists of plastic (Derraik, 2002; Hardesty & Wilcox, 2017). High concentrations of floating plastic have been reported in the central areas of the Pacific Ocean (Cozar et al., 2014). Plastic pollution found in the oceans is primarily dominated by particles smaller than 1 centimeter, commonly referred to as microplastics (Hidalgo-Ruz et al., 2012). Other researchers have defined microplastics as particles with a diameter ranging from a few micrometers up to 5 millimeters (mm) that are not readily visible to the naked eye (Andrady, 2015). Microplastic fragments and fibers found throughout the oceans result from the breakdown of larger items, such as clothing, packaging, and rope and have accumulated in the pelagic zone and sedimentary habitats (Thompson et al., 2004). Results from the investigation by Browne et al. (2011) have also suggested that microplastic fibers are discharged in sewage effluent resulting from the washing of synthetic fiber clothes. DeForges et al. (2014) sampled the Northeast Pacific Ocean in areas in and near the coastal waters of British Columbia, Canada, and found microplastics (those 62–5,000 micrometers in size) were abundant in all samples with elevated concentrations near urban centers. This finding should be applicable to all urban centers in the Pacific, including those in the Study Area. Besseling et al. (2015) documented the first occurrence of microplastics in the intestines of a humpback whale; while the primary cause of the stranding was not determined, the researchers found multiple types of microplastics ranging in sizes from 1 mm to 17 centimeters. There is still a large knowledge gap about possible negative effects of microplastics, but it remains a concern (Besseling et al., 2015). Specifically, the propensity of plastics to absorb and concentrate dissolved pollutant chemicals, such as persistent organic pollutants, is a concern because microfauna may be able to digest plastic nanoparticles, facilitating the delivery of dissolved pollutant chemicals across trophic levels and making them bioavailable to larger marine organisms, such as marine mammals (Andrady, 2015).

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

Mysticetes

3.4.1.8 Blue Whale (*Balaenoptera musculus*)

3.4.1.8.1 Status and Management

The blue whale is listed as endangered under the ESA and as depleted under the MMPA throughout its range, but there is no designated critical habitat for this species. NMFS has determined that more research is still needed to rigorously and specifically define the features that make habitat important to blue whales (National Marine Fisheries Service, 2018b). Although the designated Central North Pacific Stock of blue whales are present in winter in “lower latitudes in the western and central Pacific, including Hawaii," blue whales in the Study Area have not been assigned to a stock in either the Alaska or Pacific SARs (Carretta et al., 2017d; Muto et al., 2017b).

3.4.1.8.2 Geographic Range and Distribution

Blue whales inhabit all oceans and typically occur in both nearshore and deep oceanic waters. Blue whales belonging to the Central Pacific Stock feed in summer in the Pacific south of the Aleutian Islands and in the Gulf of Alaska, and then migrate to lower latitudes in the winter. There are no recent sighting records for blue whales in the Study Area (Fulling et al., 2011; Hill et al., 2017a; Uyeyama, 2014). Although rare, acoustic detections from passive monitoring devices deployed at Saipan and Tinian have recorded the presence of blue whales over short periods of time (a few days) (Oleson et al., 2015). However, since blue whale calls can travel up to 621 miles (mi.) (1,000 kilometers [km]), it is unknown whether the animals were actually within the Study Area. Blue whales would be most likely to occur in the Study Area during the winter and are expected to be few in number.

3.4.1.8.3 Population and Abundance

Widespread whaling over the last century was believed to have decreased the global blue whale population to approximately 1 percent of its pre-whaling population size (Branch, 2007; Monnahan, 2013; Monnahan et al., 2014; Rocha et al., 2014; Širović et al., 2004). The most current information suggests that following the cessation of commercial whaling in 1971, the population in the North Pacific may have recovered and since the 1990s has been at a stable level despite the impacts of ship strikes, interactions with fishing gear, and increased levels of ambient sound in the Pacific Ocean (Campbell et al., 2015; Carretta et al., 2017c; Carretta et al., 2018b; International Whaling Commission, 2016; Monnahan, 2013; Monnahan et al., 2014; Monnahan et al., 2015; Rockwood et al., 2017; Širović et al., 2015). For the portion of the population present in the eastern Pacific, findings have suggested that the population is now near the environment's carrying capacity and that the rate of change of the population size has declined as a result (Carretta et al., 2018b; International Whaling Commission, 2016; Monnahan et al., 2014; Monnahan et al., 2015).

3.4.1.8.4 Predator-Prey Interactions

Blue whales feed almost exclusively on various types of zooplankton, especially krill (Jefferson et al., 2015). Blue whales with data recording tags have been recorded feeding from the surface to depths approaching 300 m (Goldbogen et al., 2013a; Goldbogen et al., 2013b).

Blue whales have been documented to be preyed on by killer whales, and 25 percent of photo-identified whales in the Gulf of California carry rake scars from killer whale attacks (Jefferson et al., 2015; Pitman et al., 2007; Sears & Perrin, 2009).

3.4.1.8.5 Species-Specific Threats

Blue whales are susceptible to entanglement in fishing gear and ship strikes (Berman-Kowalewski et al., 2010; Calambokidis et al., 2009a; Calambokidis, 2012; Carretta et al., 2013; Carretta et al., 2016b; Laggner, 2009; Monnahan et al., 2015; National Marine Fisheries Service, 2011e; Rockwood et al., 2017).

3.4.1.9 Bryde's Whale (*Balaenoptera edeni*)

3.4.1.9.1 Status and Management

Bryde's whales are not listed as endangered under the ESA. There is currently no biological basis for defining separate stocks of Bryde's whales in the western or central North Pacific. (Carretta et al., 2017c; Carretta et al., 2017d; Constantine et al., 2018). NMFS recognizes two stocks of Bryde's whales in the

Pacific with one for Hawaiian waters and the other for the Gulf of California and waters off California (Carretta et al., 2017c; Carretta et al., 2017d); none of the ranges described for these stocks include the Study Area.

3.4.1.9.2 Geographic Range and Distribution

Data suggest that winter and summer grounds partially overlap in the central North Pacific (Murase et al., 2015). Bryde's whales are distributed in the central North Pacific in summer; the southernmost summer distribution of Bryde's whales inhabiting the central North Pacific is about 20° N (Kishiro, 1996). Some whales remain in higher latitudes (around 25° N) in both winter and summer, but are not likely to move poleward of 40° N (Jefferson et al., 2015; Kishiro, 1996). Bryde's whales are expected to be present in the Study Area based on sighting records (Fulling et al., 2011; Hill et al., 2017a; Mobley, 2007; Oleson & Hill, 2010a; Uyeyama, 2014). Bryde's whales were detected in the Transit Corridor between the Study Area and Hawaii during a NMFS survey in January 2010 (Oleson & Hill, 2010a) and regularly encountered during the 2007 survey of the MITT Study Area[2] (Fulling et al., 2011). Bryde's whales were encountered during a NMFS cetacean survey in May–June 2015 off Pagan, Alamagan, and south of Guam (Hill et al., 2018b; Oleson, 2017), and later that same year off Rota during a small boat survey in August–September 2015 (Hill et al., 2017a). In May 2017 a single individual was encountered in deep water off the west side of Saipan (Hill et al., 2018a).

3.4.1.9.3 Population and Abundance

Based on the best available science, there are an estimated 233 (Coefficient of Variation [CV] = 0.45) Bryde's whales present in the Study Area (Fulling et al., 2011).

3.4.1.9.4 Predator-Prey Interactions

Bryde's whales primarily feed on schooling fish and are lunge feeders. Prey includes anchovy, sardine, mackerel, herring, krill, and other invertebrates, such as pelagic red crab (Baker & Madon, 2007; Nemoto & Kawamura, 1977). Bryde's whales have been observed using "bubble nets" to herd prey (Kato & Perrin, 2009). 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 whales 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 (Weller, 2009).

3.4.1.9.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Bettridge et al., 2015; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that four products contained

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[2] The Mariana Islands Sea Turtle and Cetacean Survey (MISTCS) undertaken in 2007 covered an area of approximately 301,300 square kilometers within the larger MITT Study Area, which encompasses approximately 1,300,000 square kilometers; see Chapter 2 (Description of Proposed Action and Alternatives) for more details with regard to the extent of the MITT Study Area. The MISTCS abundance estimates from the 2007 survey as reported in Fulling et al. (2011) and cited throughout this section, thus represent the number of marine mammals estimated to be present in the approximately 24 percent of the MITT Study Area covered by the MISTCS survey.

Bryde's whale meat (Baker et al., 2006a). There has been one recorded stranding of a Bryde's whale (at Tinian in 2005) within the Study Area (Trianni & Tenorio, 2012).

3.4.1.10 Fin Whale (*Balaenoptera physalus*)

3.4.1.10.1 Status and Management

Fin whales are listed as endangered under the ESA, but there is no designated critical habitat for this species. The stock structure of fin whales remains uncertain (Mizroch et al., 2009), and fin whales in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2017d; Muto et al., 2017b). NMFS recognizes three stocks of fin whales in the North Pacific (Carretta et al., 2017d; Muto et al., 2017b), and none of the ranges described for these stocks include the Study Area.

3.4.1.10.2 Geographic Range and Distribution

Fin whales prefer temperate and polar waters; they are rarely seen in warm, tropical waters and are not expected south of 20°N latitude (Miyashita et al., 1996; Reeves et al., 2002). There are no sighting records for fin whales in the Study Area (Fulling et al., 2011; Hill et al., 2017a; Oleson et al., 2015; Uyeyama, 2014). Based on acoustic detections, fin whales are expected to be seasonally present in the Study Area although few in number. Acoustic detections from passive monitoring devices deployed at Saipan and Tinian have recorded the presence of fin whales over short (a few days) periods of time (Oleson et al., 2015), and fin whale vocalizations were detected in January 2010 in the Transit Corridor between Hawaii and Guam (Oleson & Hill, 2010a). Fin whales were not, however, detected in the Transit Corridor using the same equipment and methods in May of that year (Oleson & Hill, 2010a).

3.4.1.10.3 Population and Abundance

There is no current abundance estimate available for fin whales in the Study Area (Carretta et al., 2017d; Muto et al., 2017b).There were approximately 50,000 reported fin whales killed during commercial whaling in the North Pacific from 1911 to 1985 (C. Allison, pers. comm. as provided in Mizroch et al. (2009), and it is assumed the population is still recovering.

3.4.1.10.4 Predator-Prey Interactions

Fin whale prey vary by region and may include krill, small invertebrates such as copepods, squid, and schooling fish such as capelin, herring, pollock, and mackerel (Goldbogen et al., 2006; Jefferson et al., 2015; Mizroch et al., 2009).

The fin whale is not known to have a significant number of predators. 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 de Soto et al., 2008).

3.4.1.10.5 Species-Specific Threats

Fin whales are susceptible to entanglement in fishing gear (Carretta et al., 2013; Carretta et al., 2016b; Carretta et al., 2017a; Helker et al., 2015). Given this and as discussed in Section 3.4.1.7.3 (Bycatch) for other species, entanglement risk includes fishing activities out of Japan and South Korea.

3.4.1.11 Humpback Whale (*Megaptera novaeangliae*)

3.4.1.11.1 Status and Management

Humpback whales in the Study Area are indirectly addressed in the Alaska SAR given that the historic range of humpbacks in the "Asia wintering area" includes the Mariana Islands. The detected presence of humpbacks in the Mariana Islands (Fulling et al., 2011; Hill et al., 2016a; Hill et al., 2017a; Hill et al., 2018a; Klinck et al., 2016a; Munger et al., 2014; Oleson et al., 2015; Uyeyama, 2014) are consistent with the Study Area as a plausible migratory destination for humpback whales from Alaska (Muto et al., 2017a; Muto et al., 2017b).

Effective as of October 11, 2016, NMFS changed the status of all humpback whales from an endangered species to a specific status for each of 14 newly identified distinct population segments (DPS) (81 FR 62259). For the Study Area, the Navy believes it is likely that humpback whales in the Mariana Islands are part of the endangered Western North Pacific DPS based on the available science (Bettridge et al., 2015; Calambokidis et al., 2008; Calambokidis et al., 2010; Carretta et al., 2017c; Carretta et al., 2017d; Hill et al., 2017b; Muto et al., 2017a; Muto et al., 2017b; National Marine Fisheries Service, 2016e; National Oceanic and Atmospheric Administration, 2015a, 2018c; Wade et al., 2016). Humpback whales from the winter range of the Western North Pacific DPS (including the Study Area) that feed in the summer off Russia and Alaska have been designated by NMFS as the Western North Pacific Stock (Muto et al., 2017a; Muto et al., 2017b). As part of the Western North Pacific Stock, the population is considered depleted under the MMPA (Muto et al., 2017a; Muto et al., 2017b).

There has been no critical habitat designated for the Western North Pacific Distinct Population Segment.

3.4.1.11.2 Geographic Range and Distribution

Between 1948 and 1979, Soviet Union commercial whaling alone took 7,344 humpback whales from the North Pacific (Ilyashenko & Chapham, 2014). It is therefore likely that humpback whales in the western North Pacific are still recovering and will remain rare in parts of their former range. Researchers have reported that it is not clear whether humpback whales use the Mariana Islands as a winter breeding and calving area or as a corridor from one or more wintering areas when moving to summertime feeding area locations, which are also unknown (Hill et al., 2016a).

For purposes of the analysis presented in this SEIS/OEIS, the Navy assumes humpback whales in the Study Area are part of the endangered Western North Pacific DPS.[3] This population segment is based on a known breeding group of individuals found off Okinawa and Ogasawara Islands (approximately 1,230 nautical miles [NM] north of Guam) in Japan waters and in Philippine waters (approximately 1,350 NM west of Guam), as identified by photographic identification of individuals (Calambokidis et al., 2008; Calambokidis et al., 2010), in addition to an “unknown breeding group” from a location in the western North Pacific that remained unidentified until recently (National Oceanic and Atmospheric Administration, 2018c). Humpback whales found off Okinawa, Ogasawara, the Philippines, and the unknown area were combined to form the Western North Pacific population (Bettridge et al., 2015). This “unknown area” corresponds to the historical range for the western North Pacific that included waters extending from the South China Sea east through the Philippines, the Ryukyu Islands, Mariana

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[3] There is reference to a “Second West Pacific DPS” in the latest NMFS humpback whale status report (Bettridge et al., 2015), although that terminology did not carry over into the rule-making establishing the 14 distinct population segments. As a result, although the humpback whales in the Study Area may exactly fit the parameters of the intended “Second West Pacific DPS,” in this SEIS/OEIS the Navy has assumed that humpback whales in the Study Area are part of the Western North Pacific Distinct Population Segment consistent with the determinations presented in 81 FR 62259, the range for the Western North Pacific Stock as presented in the Alaska Stock Assessment Report (Muto et al., 2017a; Muto et al., 2017b; Muto et al., 2018), and the findings based on a series of small boat surveys in the Mariana Islands (National Marine Fisheries Service, 2018c).

Islands, and Marshall Islands and from there, north to the Arctic (Muto et al., 2017a; Muto et al., 2017b; Rice, 1998). Genetic and photographic data collected during Navy-funded small boat surveys has provided matches to individuals identified many years previously off the Ogasawara Islands and the Western North Pacific DPS (Hill et al., 2017a; Hill et al., 2017b; Hill et al., 2018a).

Navy aerial monitoring surveys occurring at Farallon de Medinilla conducted monthly from 1997 to 2009 and irregularly thereafter documented the occasional presence of humpback whales, including mother-calf pairs and other adult individuals (Uyeyama, 2014). Shipboard survey in the MITT Study Area in February 2007 acoustically detected and subsequently sighted an estimated group of eight humpbacks at Marpi Reef north of Saipan (Fulling et al., 2011; Norris et al., 2012a, 2014). Small boat surveys in 2010 and 2014 off Guam, Saipan, Tinian, Aguijan, and Rota did not encounter humpback whales (Hill et al., 2014). The next documented observations of humpback whales in the Mariana Islands occurred from February 26 to March 8, 2015, when four mother/calf pairs and four other individual humpback whales were observed at Chalan Kanoa Reef off Saipan (Hill et al., 2015a; Hill et al., 2016b). During the subsequent NMFS Mariana Archipelago Cetacean Survey (two months later; May 8 to June 6, 2015), survey transects sampling all the Mariana Islands out to 50 NM from shore detected no humpback whales visually or acoustically in the Mariana Islands (Hill et al., 2018b; Oleson, 2017). Humpback whales were seen again off Saipan during Navy-funded surveys in 2016, 2017, and 2018 (Hill et al., 2017a; Hill et al., 2017b; Hill et al., 2018a; National Oceanic and Atmospheric Administration, 2018c); see Appendix I (Geographic Mitigation Assessment) for additional details regarding all humpback whale sightings in the MITT Study Area. These Navy-funded small boat survey investigations have included photo-identification and genetic sampling and have resulted in the documentation of mother-calf pairs, competitive groups, and 35 additional photo-identified non-calf whales (Fulling et al., 2011; Hill et al., 2017a; Hill et al., 2017b; Hill et al., 2018a; National Oceanic and Atmospheric Administration, 2018c; Norris et al., 2012a, 2014). The presence of newborn calves and competitive groups documented during the aforementioned small boat surveys confirm the Mariana Islands are serving as a breeding location for Western North Pacific DPS humpback whales (National Oceanic and Atmospheric Administration, 2018c). Investigations in Hawaii over consecutive breeding seasons between 1997 through 2008 in the Maui Basin found a preference by individual mother-calf pairs for both water depth and sea-bed terrain type, with the pair moving into deeper water and rougher terrain as a calf matured (Pack et al., 2017); this habitat preference by mother-calf pairs may also be present in the Mariana Islands.

Based on a compendium of all detections, humpback whales have been sighted in the Study Area in the months of January through March (U.S. Department of the Navy, 2005; Uyeyama, 2014), male humpback songs have been recorded from December through April, and humpback whale sounds were infrequently detected at Tinian during June to October (Hill et al., 2017a; Klinck et al., 2016a; Munger et al., 2014; Norris et al., 2014; Oleson et al., 2015). Humpback whales were not observed or acoustically detected in the Transit Corridor during a May 2010 survey (Oleson & Hill, 2010a), which is consistent with the presumption that, except when migrating to or from summer feeding areas, humpback whales will most likely be present in relative shallow water locations in the vicinity of the Mariana Islands.

Humpback whales from the Western North Pacific, Hawaii, and Mexico DPSs overlap to some extent on feeding grounds off Alaska (Bettridge et al., 2015; Muto et al., 2017a; Muto et al., 2017b; National Marine Fisheries Service, 2016a; Titova et al., 2017; Wade et al., 2016). Photographic identification data have also documented the presence of at least one whale seen multiple years off Ogasawara (Japan) later seen feeding off British Columbia (Darling et al., 1996), indicating there may be greater overlap of DPSs in the summer feeding areas than has been characterized in the SARs for Alaska and the Pacific

(Carretta et al., 2017c; Carretta et al., 2017d; Carretta et al., 2018a; Muto et al., 2017a; Muto et al., 2017b). Comparison of photographic identification data from Russian waters (where the Western North Pacific DPS humpback whales may also feed) has found 35 individual whales that were also documented in Hawaii and 11 that were from the Mexican breeding grounds (Titova et al., 2017).

3.4.1.11.3 Population and Abundance

Based on photographic identifications off Okinawa and Ogasawara gathered previously and conclusions reached in 2008 (Calambokidis et al., 2008), the abundance of humpback whales in the Western North Pacific population was estimated to be approximately 1,000 individuals (Bettridge et al., 2015; Muto et al., 2017a). From that same data set, the growth rate of the Western North Pacific Distinct Population Segment was estimated to be 6.9 percent (Bettridge et al., 2015; Calambokidis et al., 2008). This can be viewed in context of the North Pacific population, which has been increasing at a rate of between 5.5 percent and 6.0 percent per year, approximately doubling every 10 years (Bettridge et al., 2015; Muto et al., 2017a; Wade et al., 2016).The inclusion of more recent data from photographic identifications off Okinawa has documented the presence of at least 1,402 unique individuals in the Western North Pacific Distinct Population Segment (Kobayashi et al., 2016). Additional information from Navy-funded surveys and passive acoustic hydrophone recordings in the Mariana Islands has confirmed the presence of mother-calf pairs, non-calf whales, and singing males in the Study Area (Fulling et al., 2011; Hill et al., 2016a; Munger et al., 2014; Munger et al., 2015; National Oceanic and Atmospheric Administration, 2018c; Norris et al., 2014; Oleson & Hill, 2010a; Oleson et al., 2015; Uyeyama et al., 2012). The NMFS Alaska SAR provides a population estimate for humpbacks in Ogasawara Islands, Okinawa, and the Philippines of 1,107 animals, with a minimum population of 865, noting that these are likely to be an underestimate of the Western North Pacific Stock's true abundance (Muto et al., 2017a; Muto et al., 2017b). Although not specific to the Study Area, the overall abundance of humpback whales in the North Pacific was recently estimated at 21,808 individuals (Carretta et al., 2017c; Carretta et al., 2017d), 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; Bettridge et al., 2015; Muto et al., 2017a; Muto et al., 2017b; Wade et al., 2016).

3.4.1.11.4 Predator-Prey Interactions

When on the summer feeding grounds in Alaska, humpback whales from the Study Area feed on a wide variety of invertebrates and small schooling fishes. The most common invertebrate prey are krill (tiny crustaceans); the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham & 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).

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 (Jefferson et al., 2015; Steiger et al., 2008).

3.4.1.11.5 Species-Specific Threats

Based on data from Alaska (including the Western North Pacific Stock), Hawaii, and the U.S. Pacific coast (Bradford & Lyman, 2015; Carretta et al., 2016c; Carretta et al., 2017b; Helker et al., 2017), humpback whales are subject to risk from entanglement in marine debris and active fishing gear; most often recorded is pot/trap fishery gear. As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under

Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that three products contained humpback whale meat (Baker et al., 2006a).

The mean vessel collision mortality and serious injury rate in Alaska is 4.3 humpback whales annually (Muto et al., 2017a), but that rate reflects Southeast Alaska waters where the presence of the Western North Pacific Stock is less likely.

3.4.1.12 Minke Whale (*Balaenoptera acutorostrata*)

3.4.1.12.1 Status and Management

Minke whales are not listed as endangered under the ESA. The stock structure for minke whales remains uncertain in the Pacific, and minke whales in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2017a; Muto et al., 2017b). NMFS recognizes three stocks of minke whales in the North Pacific: (1) the Hawaii Stock, (2) the California/Oregon/Washington Stock, and (3) the Alaska Stock (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2017a; Muto et al., 2017b).

3.4.1.12.2 Geographic Range and Distribution

Surveys employing towed hydrophone arrays and sonobuoys, and long-term monitoring efforts using fixed passive acoustic recording devices, have routinely detected the presence of minke whales in the Study Area (Klinck et al., 2016b; Norris et al., 2017; Oleson & Hill, 2010a; Oleson et al., 2015). Minke whales have not been visually detected in the Study Area during any survey efforts within approximately the last decade although they are the most common acoustically detected mysticete in the area (Fulling et al., 2011; Hill et al., 2011; Hill et al., 2013a; Hill et al., 2014; Hill et al., 2015b; Hill et al., 2017a; Mobley, 2007; Norris et al., 2014; Oleson & Hill, 2010a; Tetra Tech Inc., 2014; Uyeyama, 2014).

3.4.1.12.3 Population and Abundance

No estimates have been made for the number of minke whales in the North Pacific (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2017a; Muto et al., 2017b). Acoustic data collected during a Navy-funded 2007 line-transect survey employing a towed hydrophone array in the Mariana Islands were used to estimate a minimum abundance of calling minke whales (Norris et al., 2017). Abundance was estimated using two different methodologies, resulting in minimum estimates of 80 or 91 animals in the surveyed area (a density of 0.13 and 0.15 animals per 1,000 km^2, respectively; CV = 0.34) (Norris et al., 2017). This study provided the first abundance and density estimates for calling minke whales and the first minimum estimates by which the number of minke whales in the Mariana Islands region could be derived.

3.4.1.12.4 Predator-Prey Interactions

3.4.1.12.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk for the population of minke whales includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Dalebout et al., 2002a; Lukoschek et al., 2009). For example in 2008, the reported bycatch in Japan and South Korea totaled 214 minke whales (Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that 230 products contained minke whale meat (Baker et al., 2006a). In the two-year period between 2013 and 2014, the total bycatch by South Korean fisheries in the East Sea totaled a reported 48 minke whales (Song, 2017).

3.4.1.13 Omura's Whale (*Balaenoptera omurai*)

3.4.1.13.1 Status and Management

Omura's whale is not listed under the ESA and is not mentioned in the Pacific or Alaska SARs (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2017a; Muto et al., 2017b). There is no managed stock or population within U.S. waters pursuant to the MMPA, but the species is protected under that statute nonetheless, as are all marine mammals.

3.4.1.13.2 Geographic Range and Distribution

The species was first described in 2003 based on eight specimens taken by Japanese research whaling vessels in the Sea of Japan, the Solomon Sea, and the eastern Indian Ocean (Wada et al., 2003). Records of the species from Philippines shore-based whaling provide additional indication of a broad distribution that includes the western Pacific (Cerchio et al., 2015). Given the documented occurrence of the species, it is assumed the species may be present in the Study Area. Recent well-documented sightings have occurred in nearshore waters off Madagascar and off Sri Lanka, indicating in those cases a preference for relatively shallow water less than approximately 200 m in depth (Cerchio et al., 2015; de Vos, 2017).

3.4.1.13.3 Population and Abundance

There are no data available to estimate abundance for Omura's whale in the Study Area.

3.4.1.13.4 Predator-Prey Interactions

Observations of feeding Omura's whales in waters off Madagascar suggested the animals were skim feeding on zooplankton given there was an absence of fish or other observable prey (Cerchio et al., 2015).

3.4.1.13.5 Species-Specific Threats

An individual Omura's whale observed in Sri Lanka waters showed evidence of an entanglement scar on the left side of its upper jaw, indicating that entanglement is a potential threat for this species (Cerchio et al., 2015; de Vos, 2017). One Omura's whale was reported struck by a fishing boat in the Philippines (Obusan et al., 2016).

3.4.1.14 Sei Whale (Balaenoptera borealis)

3.4.1.14.1 Status and Management

Sei whales are listed as endangered under the ESA, but there is no designated critical habitat for this species. The stock structure for sei whales is uncertain in the Pacific (Carretta et al., 2017c; Carretta et al., 2017d). NMFS recognizes three stocks of sei whales in the North Pacific: (1) the Hawaii Stock, (2) the California/Oregon/Washington Stock, and (3) the Alaska Stock (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2017a; Muto et al., 2017b). The western Pacific and waters within the Study Area have not been addressed by NMFS, and sei whales in the Study Area have not been assigned to a stock (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2017a; Muto et al., 2017b).

3.4.1.14.2 Geographic Range and Distribution

In a January-February survey in 1972, a single group of approximately 13 sei whales were sighted during a survey of the Mariana Islands and Ogasawara (Masaki, 1972). In the 2007 survey of the Mariana Islands (Fulling et al., 2011), a total of 16 sei whales were sighted. Sei whale calls documented during the

2007 survey indicated a greater variability in the vocal repertoire of sei whales than documented elsewhere (Norris et al., 2014), which may have contributed to the lack of acoustic detections in the three-year record from 2010 to 2013 (Oleson et al., 2015). Sei whales were also visually detected in the Transit Corridor between the Study Area and Hawaii during a NMFS survey in January 2010 (Oleson & Hill, 2010a).

3.4.1.14.3 Population and Abundance

During a 2007 systematic survey of the Study Area, sei whales were sighted on 16 occasions with a resulting abundance estimate of 166 individuals (CV = 0.49) (Fulling et al., 2011).

3.4.1.14.4 Predator-Prey Interactions

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, 1987; Horwood, 2009; Nemoto & Kawamura, 1977). Feeding occurs primarily around dawn, which appears to be correlated with vertical migrations of prey species (Horwood, 2009). As with other mysticetes, sei whales have been observed lunging and gulping dense concentrations of prey, but more often tend to obtain prey by skimming (Horwood, 2009). Sei whales, like other large baleen whales, are likely subject to occasional attacks by killer whales.

3.4.1.14.5 Species-Specific Threats

Based on the discovery of a sei whale entangled in rope and fishing gear in Hawaii that presumably came from Alaska (Bradford & Lyman, 2015), sei whales may be subject to entanglement from fishery activity taking place in the western Pacific, including the Study Area. Based on the statistics of other large whales along the U.S. Pacific coast and Alaska (Carretta et al., 2016b; Carretta et al., 2017b; Helker et al., 2017), it is likely that ship strikes also pose a threat to sei whales in the Study Area from commercial vessels transiting that area.

Odontocetes

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

3.4.1.15.1 Status and Management

Blainville's beaked whale is not listed under the ESA. The stock structure for Blainville's beaked whales remains uncertain in the western Pacific, and Blainville's beaked whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d). NMFS recognizes a single stock of Blainville's beaked whales in the Pacific in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.15.2 Geographic Range and Distribution

Blainville's beaked whales are one of the most widely distributed of the toothed whales within the *Mesoplodon* genus, occurring in temperate and tropical deep waters areas in all oceans (Jefferson et al., 2015; MacLeod, 2000; MacLeod & Mitchell, 2006). In Hawaii, some populations have been documented to be long-term residents to particular areas (Baird et al., 2009b; Baird, 2011; Baird et al., 2015; McSweeney et al., 2007). There were two *Mesoplodon* 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 the 2015 NMFS survey of the Mariana Islands, two groups of Blainville's beaked whales were identified and photographed in addition to seven other beaked whale sightings identified only as *Mesoplodon* beaked whales (Hill et al., 2018b; Oleson, 2017). During Navy-funded 2010–2018 small boat surveys in the Mariana Islands, five *Mesoplodon* beaked whales were encountered on two occasions in a median depth of approximately 1,140 m and median approximate distance from shore of 15 km (Hill et al., 2013a; Hill et al., 2017a; Hill et al., 2018b). It could not be determined if these were Blainville's beaked whales or ginkgo-toothed beaked whales, both of which belong to the genus *Mesoplodon* and are believed to be present in the Study Area. Acoustic monitoring has indicated that Blainville's beaked whales occur regularly and year-round in the Study Area (Klinck et al., 2016b; Oleson et al., 2015; Tetra Tech Inc., 2014). Although there is no record of similar occurrences in the Mariana Islands, it has been suggested that the Philippines are a stranding "hot spot" for Blainville's beaked whales in Asia (Bachara & Blatchley, 2018).

3.4.1.15.3 Population and Abundance

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

3.4.1.15.4 Predator-Prey Interactions

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 & Mead, 1996; Jefferson et al., 2015; Werth, 2006a, 2006b). Feeding may also occur at mid-water as shown by tagging data from Blainville's beaked whales (Baird et al., 2005; Baird et al., 2006c). Blainville's beaked whales are known to echolocate in groups when they are on foraging dives, which makes them more easily detectable by passive acoustic means (Moretti & Baird, 2015). *Mesoplodon* beaked whales have been observed being actively preyed upon by killer whales (Wellard et al., 2016).

3.4.1.15.5 Species-Specific Threats

There were five observed interactions between an unidentified beaked whale, unidentified Mesoplodont beaked whale, or Blainville's beaked whale and longline fishing activities in Hawaiian waters between 2010 and 2014 (Bradford & Forney, 2016, 2017). As similar information for U.S. fishing vessels or foreign fishing vessels in the Study Area is unavailable, this data from Hawaii provides information regarding the species interactions with fishing activities in general. As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated at least one product contained Blainville's beaked whale meat (Baker et al., 2006a).

3.4.1.16 Common Bottlenose Dolphin (*Tursiops truncatus*)

3.4.1.16.1 Status and Management

Bottlenose dolphin is not listed under the ESA. The stock structure for bottlenose dolphin remains uncertain in the western Pacific and the Mariana Islands (Martien et al., 2014b), and bottlenose dolphins in the Study Area have not been assigned to a stock in the current Pacific SAR (Carretta et al., 2017c; Carretta et al., 2017d). Other than small and resident Main Hawaiian island-associated populations of bottlenose dolphins, NMFS recognizes a single pelagic stock of bottlenose dolphin in the Pacific in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.16.2 Geographic Range and Distribution

Multiple fishery interactions with bottlenose dolphins in the western North Pacific (Miyashita, 1993b) indicated their presence beginning approximately 400 NM north of the Study Area. It is possible that bottlenose dolphins do not occur in great numbers in the Mariana Island chain, but they have been frequently sighted, although in small numbers. In the main Hawaiian Islands, data suggest that bottlenose dolphins exhibit site fidelity (Baird et al., 2009a; Baird et al., 2013c; 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, which would be similar to the MITT Study Area.

Common bottlenose dolphins are generally found in coastal and continental shelf waters of tropical and temperate regions of the world and are known to occur in small enclosed bays or harbors (Martien et al., 2012; Rossman et al., 2015; Wells & Scott, 2009), but they have not been detected in any such enclosed water in the Study Area (such as Apra Harbor). During the 2007 survey of the Mariana Islands, there were three sightings of bottlenose dolphins to the east of Saipan in deep waters near the Mariana Trench (Fulling et al., 2011). Bottlenose dolphins were not detected during the 2010 survey of the Mariana Islands and the Transit Corridor (Oleson & Hill, 2010a), but were detected on three occasions during the 2015 NMFS cetacean survey of the Mariana Islands (Hill et al., 2018b; Oleson, 2017). In total during Navy-funded 2010–2018 small boat surveys in the Mariana Islands, bottlenose dolphins were encountered on 36 occasions in a median depth of approximately 700 m and median approximate distance from shore of 7 km (Hill et al., 2017a; Hill et al., 2018a; Hill et al., 2018b). On multiple occasions, encounters with bottlenose dolphins in the Mariana Islands have involved a mixed-species aggregation with one other species that have included short-finned pilot whales, pantropical spotted dolphins, false killer whales, spinner dolphins, or rough-toothed dolphins (Hill et al., 2011; Hill et al., 2018b). In the 2017 follow-on small boat survey, three bottlenose dolphin groups consisting of two to eight individuals were encountered off Saipan in waters with a median depth of 306 m and a median distance from shore of 5.4 km (Hill et al., 2018a).

3.4.1.16.3 Population and Abundance

In some regions of the Pacific, "inshore" and "offshore" or pelagic species differ genetically and morphologically (Baird et al., 2009a; Baird et al., 2013c; Tezanos-Pinto et al., 2009), but this has not been demonstrated for the Mariana Islands (Martien et al., 2014b). A total of 4,610 photos taken during small boat surveys between 2011 and 2014 were analyzed to identify individual bottlenose dolphins. A total of 47 individuals were identified with 30 individuals (64 percent) re-encountered and the remaining 17 of those individuals (36 percent) encountered three or more times (Hill et al., 2017a). These re-encounters occurred between all islands and may be similar to the site fidelity present for some of the island-associated populations present in the Hawaiian Islands (Baird et al., 2009a). Genetic samples from 21 bottlenose dolphins encountered off Guam and Saipan in 2007 suggest a history of hybridization with Fraser's dolphin (Martien et al., 2014b). The Mariana Islands samples shared DNA haplotypes with individuals from the Philippines, South Korea, Taiwan, and the main Hawaiian Islands but precluded determination of any small populations associated with specific locations in the Mariana Islands similar to what has been found in Hawaii (Martien et al., 2014b).

A bottlenose dolphin abundance estimate of 31,700 animals was made for the area approximately 400 NM north of the Mariana Islands (Miyashita, 1993b). There were three sightings of bottlenose dolphin during a 2007 systematic survey of the Study Area, resulting in an abundance estimate of 122 animals (CV = 0.992) (Fulling et al., 2011).

3.4.1.16.4 Predator-Prey Interactions

Bottlenose dolphins are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimps (Wells & Scott, 1999, 2009), and using a variety of feeding strategies (Shane, 1990). In addition to using echolocation, bottlenose dolphins detect and orient fish prey by listening for the sounds their prey produce (i.e., 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 & Potter, 1995). Throughout their range bottlenose dolphins are known to be preyed on by killer whales and sharks (Ferguson et al., 2012; Heithaus, 2001a; Heithaus, 2001b; Sprogis et al., 2018; Wells & Scott, 1999).

3.4.1.16.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least two products contained bottlenose dolphin meat, reflecting an estimated 23 bottlenose dolphins (Baker et al., 2006a). The stranding of a single bottlenose dolphin in 2013 near Tumon, Guam, is the only known stranding for this species in the Mariana Islands area (Uyeyama, 2014).

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

3.4.1.17.1 Status and Management

Cuvier's beaked whale is not listed under the ESA. The stock structure for Cuvier's beaked whales remains uncertain in the western Pacific, and Cuvier's beaked whales in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2017a; Muto et al., 2017b). With the exception of the U.S. West Coast, NMFS only recognizes a stock of Cuvier's beaked whale in the Pacific in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d) and in the "eastern North Pacific" and Alaskan waters (Muto et al., 2017a; Muto et al., 2017b), whose distribution does not extend to the Study Area.

3.4.1.17.2 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., 2006a; Ferguson et al., 2006b; 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 feet (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). While there are indications of potential seasonal re-distribution of Cuvier's beaked whales and documented satellite tag movements in Southern California waters (Falcone & Schorr, 2014; Moretti, 2017; Schorr et al., 2014; Schorr et al., 2018), no such research findings are available from the Mariana Islands. 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 aerial surveys conducted in August 2007 covering 2,352 km of linear effort, 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 (the taxon that Cuvier's beaked whales belong to) was observed in deep water during the 2007 shipboard survey of the Study Area but was not identified to the species level (Fulling et al., 2011). A single Cuvier's beaked whale was sighted and others acoustically detected during an August 2013 survey at Pagan Island (Tetra Tech Inc., 2014). A year's duration of acoustic monitoring at Saipan and at Tinian recorded vocalizing Cuvier's beaked whales (Oleson et al., 2015). These vocalizations were detected in all months having sufficient samples to detect their presence in the Study Area, suggesting there is no seasonal aspect to the Cuvier's beaked whale's distribution.

3.4.1.17.3 Population and Abundance

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

3.4.1.17.4 Predator-Prey Interactions

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

Cuvier's beaked whales may be preyed upon by killer whales (Heyning & Mead, 2009; Jefferson et al., 2008).

3.4.1.17.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least one product contained Cuvier's beaked whale meat (Baker et al., 2006a).

Cuvier's beaked whales were found stranded on Saipan in 2007, on Rizal Beach, Guam, in 2008 (*Ziphius* sp.), and two were found (one alive and one dead) on Micro Beach, Saipan, in 2011 (Uyeyama, 2014). A necropsy conducted on one of the 2011 stranded animals revealed abnormalities in the animal's kidneys and intestines (Hawaii Pacific University, 2012; Saipan Tribune, 2011). Two strandings of Cuvier's beaked whales occurred in 2015; one in March and one in July. The individual that stranded in March 2015 had a severe Crassicauda (nematode) infestation in its kidneys (West, 2018). The individual stranded in July 2015 was not accessible for transport until days after the stranding and, because of the resulting decomposition, necropsy and histopathology was not conducted for this whale (West, 2018).

3.4.1.18 Dwarf Sperm Whale (*Kogia sima*)

3.4.1.18.1 Status and Management

Dwarf sperm whale is not listed under the ESA. The stock structure for dwarf sperm whales remains uncertain in the western Pacific, and dwarf sperm whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d). Other than for waters along the U.S. West Coast, NMFS recognizes a single stock of dwarf sperm whale in the Pacific in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.18.2 Geographic Range and Distribution

Records of this species have been documented from the western Pacific (Taiwan and Japan) (Sylvestre, 1988; Wang et al., 2001; Wang & Yang, 2006), and there have been four known dwarf sperm whale strandings in the Mariana Islands (Trianni & Tenorio, 2012; Uyeyama, 2014).

There were no species of *Kogia* sighted during the 2007 shipboard survey of the Study Area, although this cryptic species is difficult to detect, particularly in the high sea states that are normally present in the Mariana Islands (Fulling et al., 2011). Aerial surveys in August 2007 covering 2,352 km of linear effort encountered three dwarf sperm whales (Mobley, 2007). In total during Navy-funded 2010–2016 small boat surveys in the Mariana Islands, five dwarf sperm whales have been encountered on four occasions in a median depth of approximately 750 m and at a median distance of approximately 3 km from shore (Hill et al., 2017a).

3.4.1.18.3 Population and Abundance

There are no abundance estimates for dwarf sperm whales in the Study Area.

3.4.1.18.4 Predator-Prey Interactions

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

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

3.4.1.18.5 Species-Specific Threats

Based on data collected in Hawaiian waters, dwarf sperm whales are susceptible to injury or mortality from fisheries interactions (Bradford & Forney, 2014, 2017). It is assumed that fishery activities in the Study Area pose a similar threat to the species.

3.4.1.19 False Killer Whale (*Pseudorca crassidens*)

3.4.1.19.1 Status and Management

The population of false killer whales in the Mariana Islands is not listed under the ESA. The stock structure for false killer whales remains uncertain in the western Pacific (Chivers et al., 2007; Martien et al., 2014a), and false killer whales in the Study Area have not been assigned to a stock in the current SAR for the Pacific (Carretta et al., 2017c; Carretta et al., 2017d). NMFS recognizes multiple stocks of false killer whale in the Pacific within the U.S. Exclusive Economic Zone in Hawaiian waters, at Palmyra Atoll, and waters around America Samoa (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.19.2 Geographic Range and Distribution

The false killer whale is an oceanic species, occurring in deep waters of the North Pacific (Miyashita et al., 1996; Wang et al., 2001) but also known to occur close to shore near oceanic islands (Baird, 2012). In Hawaii, false killer whales have been seen in groups of up to 100 over a wide range of depths and distance from shore (Baird et al., 2003; Baird et al., 2013a; Bradford et al., 2014; Bradford et al., 2015; Oleson et al., 2013). 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 & 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, 2009b).

During the 2007 survey of the Study Area, there were 10 false killer whale sightings in deep water offshore locations with group sizes ranging from 2 to 26 individuals (Fulling et al., 2011). During the 2010 NMFS survey, one sighting of a pod containing five false killer whales was made approximately midway between Guam and Hawaii in the Transit Corridor (Oleson & Hill, 2010a). During the NMFS 2015 survey of the Mariana Islands, false killer whales were encountered on only two occasions, once off Asuncion

Island and once off Alamagan Island, with estimated group sizes of 6–31 individuals (Hill et al., 2018b; Oleson, 2017). In small boat surveys in the Study Area conducted between 2010 and 2018, false killer whales were encountered only on six occasions (Hill et al., 2014; Hill et al., 2017a; Hill et al., 2018b). Three reported false killer whale strandings have been reported between 1963 and 2013; these occurred in 2000, 2003, and 2007 (Trianni & Tenorio, 2012; Uyeyama, 2014).

3.4.1.19.3 Population and Abundance

There are estimated to be about 6,000 false killer whales in the North Pacific (starting approximately 50 NM off the Study Area from 25° N to 39° N latitude) based on fishery interaction data (Miyashita, 1993b). 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).

3.4.1.19.4 Predator-Prey Interactions

False killer whales feed primarily on deep-sea cephalopods and fish (Baird et al., 2008; Koen-Alonso et al., 1999; Odell & McClune, 1999). Four false killer whales found stranded in Hawaii from 2010 through 2016 had stomach contents that included prey items from various squid, yellowfin tuna, mahi mahi, jack, marlin, and bonefish (West, 2016).

False killer whales have been observed to attack other cetaceans, including dolphins and large whales, such as humpback and sperm whales (Baird, 2009a, 2009b). They are known to behave aggressively toward small cetaceans in tuna purse seine nets. 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., 2010b). This species is believed to be preyed on by large sharks and killer whales (Baird, 2009a).

3.4.1.19.5 Species-Specific Threats

Based on a historic decline in the number of false killer whales in Hawaii, which is believed to have been the result of various factors that include incidental take by commercial fisheries (Bradford et al., 2014; Bradford & Forney, 2017; Oleson et al., 2010; Reeves et al., 2009), it should be assumed that foreign and the limited domestic commercial longline fishing in the Study Area may also pose a similar threat to false killer whales in the Mariana Islands. (Allen & Amesbury, 2012; National Marine Fisheries Service, 2015d, 2018a; National Oceanic and Atmospheric Administration, 2018b). Necropsy results from four stranded false killer whales in Hawaii documented stomach contents that included fishing gear (hooks, leaders, and line) in two of the four animals (West, 2016). As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least 19 products contained false killer whale meat (Baker et al., 2006a). In the two-year period between 2013 and 2014, the total bycatch by South Korean fisheries in the East Sea totaled one false killer whale (Song, 2017).

3.4.1.20 Fraser's Dolphin (*Lagenodelphis hosei*)

3.4.1.20.1 Status and Management

Fraser's dolphin is not listed under the ESA. The stock structure for Fraser's dolphin remains uncertain in the western Pacific, and Fraser's dolphin in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d). NMFS recognizes a single stock of Fraser's dolphin in the Pacific in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.20.2 Geographic Range and Distribution

Fraser's dolphin is a tropical oceanic species, except where deep water approaches the coast (Dolar, 2009). 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 (Jefferson & Leatherwood, 1994). In Hawaiian waters, Fraser's dolphin was one of the most abundant species offshore, having large pod group sizes with an observed mean of 283 animals (Bradford et al., 2017).

3.4.1.20.3 Population and Abundance

There are no abundance estimates for Fraser's dolphin in the Study Area. Genetic samples from 21 bottlenose dolphins encountered off Guam and Saipan in 2007 suggests a history of hybridization with Fraser's dolphin (Martien et al., 2014b).

3.4.1.20.4 Predator-Prey Interactions

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

3.4.1.20.5 Species-Specific Threats

There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in other locations. There is a report of a Fraser's dolphin being taken as a result of a fishery interaction in the Philippines (Obusan et al., 2016). Fraser's dolphin has been subjected to predation by killer whales in the Bahamas (Dunn et al., 2007).

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

3.4.1.21.1 Status and Management

Ginkgo-toothed beaked whale is not listed under the ESA. Due to the difficulty in distinguishing the different *Mesoplodon* beaked whale species during visual surveys, ginkgo-toothed beaked whales are combined with all other *Mesoplodon* species that occur off the U.S. West Coast and are managed by NMFS as a species guild (Carretta et al., 2017c; Carretta et al., 2017d). The stock structure for ginkgo-toothed beaked whale remains uncertain in the western Pacific, and ginkgo-toothed beaked whales present in the Study Area or the remainder of the Pacific have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.21.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit continental slope and deep ocean waters (greater than 200 m) and are only occasionally reported in waters over the continental shelf (Cañadas et al., 2002; Ferguson et al., 2006a; MacLeod & D'Amico, 2006; Pitman, 2009). Acoustic monitoring at sites around the North Pacific have encountered the "BWC type" beaked whale vocalizations, which are assumed to be produced by ginkgo-toothed beaked whales (Baumann-Pickering et al., 2012; Oleson et al., 2015). Strandings of ginkgo-toothed beaked whales are not common anywhere, but the largest number of records are from Japan (Baumann-Pickering et al., 2012); there have been no known strandings of the species in the Mariana Islands.

In total during Navy-funded 2010–2018 small boat surveys in the Mariana Islands, five *Mesoplodon* beaked whales have been encountered on two occasions in a median depth of approximately 1,140 m and median approximate distance from shore of 15 km (Hill et al., 2017a; Hill et al., 2018b); it could not be determined if these were ginkgo-toothed beaked whales, which are believed to be present in the Study Area; or Blainville's beaked whales, which have been observed elsewhere in the Mariana Islands (Hill et al., 2018b; Oleson, 2017).

A year of acoustic monitoring at Saipan and at Tinian recorded the BWC type beaked whale vocalizations assumed to be produced by ginkgo-toothed beaked whales (Oleson et al., 2015). These vocalizations were detected in all months having sufficient samples to detect their presence in the Study Area, suggesting there is no seasonal aspect to their distribution. This correlates with the findings reported from a previous acoustic monitoring site off Saipan where this same signal type was encountered during 24 percent of days sampled (Baumann-Pickering et al., 2012).

3.4.1.21.3 Population and Abundance

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

3.4.1.21.4 Predator-Prey Interactions

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 & Mead, 1996; Jefferson et al., 2015; Werth, 2006a, 2006b). Feeding may also occur at mid-water as shown from tagging data from Blainville's beaked whale habits documented in Hawaii (Baird et al., 2005; Baird et al., 2006c). *Mesoplodon* beaked whales have been observed being actively preyed upon by killer whales (Wellard et al., 2016).

3.4.1.21.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of the Philippines, Japan, and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009; Obusan et al., 2016). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated at least one product contained Blainville's beaked whale meat (Baker et al., 2006a), suggesting the same risk may be present for ginkgo-toothed beaked whales. There were five observed interactions between an unidentified beaked whale, unidentified Mesoplodont beaked whale, or Blainville's beaked whale and longline fishing activities in Hawaiian waters between 2010 and 2014 (Bradford & Forney, 2016, 2017). There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in Hawaii.

3.4.1.22 Killer Whale (*Orcinus orca*)

3.4.1.22.1 Status and Management

The stock structure for killer whales remains uncertain in the western Pacific, and killer whales present in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2017a; Muto et al., 2017b). NMFS recognizes eight stocks of killer whales for the Pacific, but none of the identified ranges are within the Study Area (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2017a; Muto et al., 2017b).

Under the ESA, the Southern Resident Distinct Population Segment of killer whales is the only species listed as endangered, but those animals do not venture beyond the North American nearshore waters. Killer whales in the Study Area are not listed pursuant to the ESA.

3.4.1.22.2 Geographic Range and Distribution

Killer whales are found in all marine habitats from inland and nearshore coastal areas, to the deep mid-ocean, and from equatorial regions to the polar pack ice zones of both hemispheres. Forney and Wade (2006) found that killer whale densities increased by one to two orders of magnitude from the tropics to the poles.

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), and the species has been reported in the tropical waters around Guam, Yap, and Palau (Rock, 1993). Between 1987 and 2017 in the Mariana Islands, killer whales in pods of three to five individuals were observed on only six occasions (Eldredge, 1991; Uyeyama, 2014). There was also a badly decomposed killer whale found stranded on Guam in August 1981 (Kami, 1982). There were no sightings of the species during a 2007 systematic line-transect survey (Fulling et al., 2011) or a 2010 survey of the area (Oleson & Hill, 2010a). In May 2010, a group of approximately five killer whales, including one calf, were observed about 20 NM south of Farallon de Medinilla (Uyeyama, 2014; Wenninger, 2010). The Navy-funded small boat surveys between 2010 and 2016 in the Mariana Islands did not encounter any killer whales (Hill et al., 2014; Hill et al., 2017a). Vocalizations from killer whales were detected on three occasions south of Guam by passive acoustic recorders aboard an underwater glider survey in 2014 (Klinck et al., 2016b).

3.4.1.22.3 Population and Abundance

There are no abundance estimates for killer whales in the Study Area.

3.4.1.22.4 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; Ford et al., 2013; Ford et al., 2014; Jefferson et al., 2015). In May 2010 during the routine Navy aerial survey of Farallon de Medinilla about 20 mi. (32 km) south of the island, a group of approximately five killer whales, including one calf, were observed feeding on a large whale carcass (Uyeyama, 2014; Wenninger, 2010). The killer whale has no known natural predators; it is considered to be the top predator of the oceans (Ford, 2008).

3.4.1.22.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least two products contained killer whale meat (Baker et al., 2006a).

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

3.4.1.23.1 Status and Management

Longman's beaked whale is not listed under the ESA. Only one stock has been identified for the Pacific for the population present in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2017b). The stock structure for Longman's beaked whale remains uncertain in the western Pacific, and the species in the Study Area has not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.23.2 Geographic Range and Distribution

Longman's beaked whales are found in warm tropical waters, and most sightings occur in waters with sea surface temperatures warmer than 78°F (26°C) (Anderson et al., 2006; MacLeod et al., 2006; MacLeod & D'Amico, 2006). Based on systematic survey data collected from 1986 to 2005 in the eastern Pacific, all Longman's beaked whale sightings were south of 25° N (Hamilton et al., 2009). Sighting records of this species in the Indian Ocean showed that Longman's beaked whales are typically found in waters over deep bathymetric slopes reaching 200–2,000 m or greater (Anderson et al., 2006).

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., 2002b; Dalebout et al., 2003; Moore, 1972). In the Pacific, records of this species indicate presence in the eastern, central, and western Pacific, including waters off the coast of Mexico and Hawaii. Longman's beaked whales have not been observed or detected acoustically in the Study Area, although it is assumed they are present in the area. In Hawaii, there was a single sighting of approximately 18 Longman's beaked whales during a NMFS 2002 survey (Barlow, 2006). During the follow-on 2010 survey, there were three sightings of Longman's beaked whales, with group sizes ranging from approximately 32 to 99 individuals (Bradford et al., 2017). It is assumed that Longman's beaked whales would have similar grouping behavior in the Study Area.

3.4.1.23.3 Population and Abundance

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

3.4.1.23.4 Predator-Prey Interactions

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 & Mead, 1996; Jefferson et al., 2015; Werth, 2006a, 2006b). Feeding may also occur at mid-water as shown by tagging data from Cuvier's and from Blainville's beaked whales in Hawaii (Baird et al., 2005; Baird et al., 2006c). *Mesoplodon* beaked whales have been observed being actively preyed upon by killer whales (Wellard et al., 2016); it is assumed this may also be the case with Longman's beaked whales.

3.4.1.23.5 Species-Specific Threats

Disease may be relatively common in Longman's beaked whales since morbillivirus was documented in a juvenile male Longman's beaked whale that stranded in Hawaii in 2010 (West et al., 2012) and in five individuals stranded in New Caledonia (Garrigue et al., 2016), and also given the small sample sizes involved in those findings.

There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in Hawaii. There were two observed interactions between unidentified beaked whales and longline fishing activities in

Hawaiian waters between 2009 and 2013 (Bradford & Forney, 2016), so it is assumed that interactions with fishing activities in the Mariana Islands may also occur. As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence from three different species of beaked whale were identified (Baker et al., 2006a).

3.4.1.24 Melon-Headed Whale (*Peponocephala electra*)

3.4.1.24.1 Status and Management

Melon-headed whale is not listed under the ESA. The stock structure for melon-headed whales remains uncertain in the western Pacific, and melon-headed whales in the Study Area have not been assigned to a stock in the current Pacific SAR (Carretta et al., 2017c; Carretta et al., 2017d). NMFS recognizes two stocks of melon-headed whales in the Pacific associated with Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.24.2 Geographic Range and Distribution

Melon-headed whales are found worldwide in tropical and subtropical waters, but movement patterns for this species are poorly understood. It has been suggested that melon-headed whales near oceanic islands rest near shore during the day and feed in deeper waters at night (Brownell et al., 2009a; Gannier, 2002; Woodworth et al., 2012). In surveys around the main Hawaiian Islands, melon-headed whales showed no clear pattern in depth use (Baird, 2013). Melon-headed whales are also known to enter shallow water areas on occasion, although these are generally characterized as animals being “out of habitat” or “mass strandings.” Such out-of-habitat events, each involving a few hundred melon-headed whales, have occurred at Sasanhaya Bay, Rota (Jefferson et al., 2006); and in Hawaii (Fromm et al., 2006; Mobley et al., 2007; Southall et al., 2006) on the same day in 2004. Similar numbers did so twice in the Philippines entering Manila Bay in February 2009 and the bay at Odiongan, Romblon in March of 2009 (Aragones et al., 2010; Obusan et al., 2016).

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). There was one sighting of approximately 53 individuals southeast of Guam and two mid-ocean sightings (pods sizes of 43 and 72) in the Transit Corridor portion of the Study Area during the large vessel Pacific Islands Fisheries Science Center survey (Oleson & Hill, 2010a). During small boat surveys in 2012 and 2014, melon-headed whales in large pods numbering between 85 and 325 individuals were sighted off Guam and Tinian/Saipan (HDR, 2012; Hill et al., 2014). The NMFS 2015 month-long survey of the Mariana Islands encountered melon-headed whales on four occasions, in offshore waters and in large pods estimated to number between 90 and 268 individuals (Hill et al., 2018b; Oleson, 2017).

There was a live stranding of a melon-headed whale on the beach at Inarajan Bay, Guam in April 1980 (Donaldson, 1983; Kami, 1982), and four individuals at Orote in 2009 (Uyeyama, 2014).

3.4.1.24.3 Population and Abundance

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

3.4.1.24.4 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 1,500 m deep, suggesting that feeding takes place deep in the water column (Baird et al., 2010a; Jefferson & Barros, 1997).

3.4.1.24.5 Species-Specific Threats

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., 2006a). The 2016 Pacific SAR (Carretta et al., 2017c; Carretta et al., 2017d) suggests that melon-headed whales may be particularly sensitive to impacts from anthropogenic sounds; see the U.S. Navy's Technical Report (U.S. Department of the Navy, 2017c) for a general discussion of strandings potentially related to the use of sonar and other anthropogenic sound.

3.4.1.25 Pantropical Spotted Dolphin (*Stenella attenuata*)

3.4.1.25.1 Status and Management

The pantropical spotted dolphin is not listed under the ESA. The stock structure for pantropical spotted dolphin remains uncertain in the western Pacific, and pantropical spotted dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d). NMFS recognizes a single pelagic stock and three Hawaiian Island-associated stocks of pantropical spotted dolphin in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d). Results from genetic analyses of pantropical spotted dolphin populations, including the Indo-Pacific and eastern tropical Pacific Ocean (including eight samples from Guam and the Northern Mariana Islands), support the current taxonomy and indicate very close genetic relationships among the Indo-Pacific populations (Leslie & Morin, 2018).

3.4.1.25.2 Geographic Range and Distribution

A survey of the Mariana Islands in 2007 encountered 17 groups of pantropical spotted dolphins, ranging in size from 1 to 115 individuals (Fulling et al., 2011). Aerial surveys in August 2007 covering 2,352 km of linear effort encountered a single pod of 30 pantropical spotted dolphins (Mobley, 2007). In total during the Navy-funded 2010 to 2016 small boat surveys in the Mariana Islands, pantropical spotted dolphins were encountered on 30 occasions in group sizes of 4–70 individuals at a median approximate distance from shore of 6 km (Hill et al., 2014; Hill et al., 2017a). Approximate satellite tag locations from a pantropical spotted dolphin in 2016 demonstrated wide-ranging use of the waters at a median of 6.1 km offshore of Guam (Hill et al., 2017a).

3.4.1.25.3 Population and Abundance

Based on sighting data from the 2007 systematic survey of the Mariana Islands, the estimated abundance for pantropical spotted dolphins in the Study Area is 12,981 (CV = 0.704) (Fulling et al., 2011).

3.4.1.25.4 Predator-Prey Interactions

Pantropical spotted dolphins prey on near-surface fish, squid, and crustaceans and on some mid-water species (Perrin & Hohn, 1994). Results from various tracking and feeding 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; Silva et al., 2016).

3.4.1.25.5 Species-Specific Threats

There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in other locations. Pantropical spotted dolphins in Hawaii and Samoa have been observed interacting with the longline fishery, resulting in injury (Bradford & Forney, 2014), and there was one case of serious injury to a spotted dolphin observed entangled in fishing line (Bradford & Lyman, 2015). Given the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

Pantropical spotted dolphins may be preyed on by killer whales and sharks and have been observed fleeing killer whales in Hawaiian waters (Baird et al., 2006b). Other predators may include the pygmy killer whale, false killer whale, and occasionally the short-finned pilot whale (Perrin, 2009b).

3.4.1.26 Pygmy Killer Whale (*Feresa attenuata*)

3.4.1.26.1 Status and Management

The pygmy killer whale is not listed under the ESA. The stock structure for pygmy killer whale remains uncertain in the western Pacific, and pygmy killer whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.26.2 Geographic Range and Distribution

This species has been documented in the western Pacific (Taiwan and Japan) (Sylvestre, 1988; Wang et al., 2001; Wang & Yang, 2006). There was only one pygmy killer whale sighting of a group of six animals during the 2007 systematic 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 between 2010 and 2016, there was a single pygmy killer whale sighting northeast of Saipan in 2011 and then single sightings in 2013 and 2014 off Guam; group sizes were from six to nine individuals (Hill et al., 2014; Hill et al., 2017a).

3.4.1.26.3 Population and Abundance

Based on a single sighting during the 2007 survey of the Study Area, pygmy killer whale abundance was estimated at 78 individuals (CV = 0.881) (Fulling et al., 2011).

3.4.1.26.4 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., 2015; Perryman & Foster, 1980; Ross & Leatherwood, 1994).

3.4.1.26.5 Species-Specific Threats

Fisheries interactions in the Study Area are likely given documented evidence from fishery activities in Hawaii (Bradford & Forney, 2017; Carretta et al., 2017c). Based on the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

The 2016 Pacific SAR (Carretta et al., 2017c; Carretta et al., 2017d) suggests that two mass strandings of pygmy killer whales (that occurred in 2004 and 2005) on Taiwan were, "…possibly associated with offshore naval training exercises" based on the citation to Wang and Yang (2006). Wang and Yang (2006) only speculatively suggested that, "…naval sonar and live ammunition exercises are two of many plausible causes that need to be investigated" given there was a lack of necessary information (such as if sonar was even in use) regarding relatively contemporaneous and distant events involving the U.S. Navy, People's Republic of China Navy, Taiwan's Republic of China Navy, Japanese Navy, and oil and gas seismic exploration occurring in the eastern Pacific. Further, between 1995 and 2005 there were a total of six pygmy killer whale Mass Stranding Events and three milling events involving the same species in Taiwan (Brownell et al., 2009b; Yang et al., 2008), confounding the identification of a specific cause for these particular stranding events. The suggestion that sonar, underwater detonations, or seismic oil and gas exploration may have caused the 2004 and 2005 strandings has remained speculative with researchers pointing to the need for further investigation (Brownell et al., 2009b; Wang & Yang, 2006; Yang et al., 2008). The technical report from the U.S. Department of the Navy (U.S. Department of the Navy, 2017c) provides a general discussion of strandings potentially related to the use of sonar and other anthropogenic sound.

The pygmy killer whale has no documented predators (Weller, 2009), although it may be subject to predation by killer whales.

3.4.1.27 Pygmy Sperm Whale (*Kogia breviceps*)

3.4.1.27.1 Status and Management

Pygmy sperm whale is not listed under the ESA. The stock structure for pygmy sperm whales remains uncertain in the western Pacific, and pygmy sperm whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d). Other than for waters along the U.S. West Coast, NMFS recognizes a single stock of pygmy sperm whale in the Pacific in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.27.2 Geographic Range and Distribution

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). The stranding of a pygmy sperm whale in 1997 (Trianni & Tenorio, 2012), is the only other confirmed occurrence of this species in the Study Area.

3.4.1.27.3 Population and Abundance

There are no abundance estimates for pygmy sperm whale in the Study Area.

3.4.1.27.4 Predator-Prey Interactions

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

Killer whales and white sharks are documented predators of pygmy sperm whales (Dunphy-Daly et al., 2008; Long, 1991; Tirard et al., 2010).

3.4.1.27.5 Species-Specific Threats

Based on data collected in Hawaiian waters, pygmy sperm whales are susceptible to injury or mortality from fisheries interactions (Bradford & Forney, 2014, 2017). It is assumed the fishery activities in the

Study Area pose a similar threat. Given the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

3.4.1.28 Risso's Dolphin (*Grampus griseus*)

3.4.1.28.1 Status and Management

Risso's dolphin is not listed under the ESA. The stock structure for Risso's dolphin remains uncertain in the western Pacific, and Risso's dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d). Other than for waters along the U.S. West Coast, NMFS recognizes a single stock of Risso's dolphins in the Pacific in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.28.2 Geographic Range and Distribution

Occurrence of this species is deep open ocean waters off Hawaii and in other locations in the Pacific (Au & Perryman, 1985; Bradford et al., 2017; Leatherwood et al., 1980; Miyashita et al., 1996; Wang et al., 2001). Fishery interaction data determined the species occurrence west of the International Date Line extended as far north as 40° N, but the southern extent of the range could not be determined (Miyashita, 1993a). Aerial surveys in August 2007 covering 2,352 km of linear effort encountered a single pod of eight Risso's dolphins (Mobley, 2007). During the NMFS survey of 2010, there was a single Risso's dolphin sighting of three individuals approximately 60 NM north of FDM (Oleson & Hill, 2010a). The 2015 NMFS month-long survey of the Mariana Islands encountered Risso's dolphins only twice and in small pods with a median group size of three (Hill et al., 2018b; Oleson, 2017). The species has not been detected in any other surveys efforts in the Study Area (Fulling et al., 2011; Hill et al., 2014; Hill et al., 2017a; Hill et al., 2018a; Hill et al., 2018b). Vocalizations from Risso's dolphins were also detected south of Guam by passive acoustic recorders aboard an underwater glider survey in 2014 (Klinck et al., 2016b).

3.4.1.28.3 Population and Abundance

There are no abundance estimates for Risso's dolphin in the Study Area.

3.4.1.28.4 Predator-Prey Interactions

Cephalopods and crustaceans are the primary prey for Risso's dolphins (Clarke, 1996), which feed mainly at night (Fernandez et al., 2017; Jefferson et al., 2015; Perrin et al., 2009). This dolphin may be preyed on by both killer whales and sharks, although there are no documented reports of predation by either species (Weller, 2009).

3.4.1.28.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least one product contained Risso's dolphin meat (Baker et al., 2006a).

3.4.1.29 Rough-Toothed Dolphin (*Steno bredanensis*)

3.4.1.29.1 Status and Management

The rough-toothed dolphin is not listed under the ESA. The stock structure for rough-toothed dolphins remains uncertain in the western Pacific, and rough-toothed dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d). NMFS recognizes a single stock of rough-toothed dolphins in the Pacific in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.29.2 Geographic Range and Distribution

Rough-toothed dolphins were sighted twice during a 2007 survey; once as nine individuals in a mixed group of short-finned pilot whales and bottlenose dolphins, and once in a pod of nine individuals with calves present (Fulling et al., 2011). A pod of eight rough-toothed dolphins was also sighted approximately 175 km south of Guam during a 2007 aerial survey (Mobley, 2007). There were no rough-toothed dolphins identified in the broad offshore survey in 2010 (Oleson & Hill, 2010a). The species was encountered only three times during the month-long 2015 NMFS survey of the islands, twice in a group with another cetacean species (Oleson, 2017). Annual small boat surveys conducted from 2010 to 2018(Hill et al., 2011; Hill et al., 2013a) have encountered rough-toothed dolphins on seven occasions, and again all but one of those encounters were in a group with other cetaceans (Hill et al., 2014; Hill et al., 2018b). Four of the same photo-identified rough-toothed dolphins encountered in 2013 have been seen multiple times since in the same general location to the west of Saipan off CK Reef (Hill et al., 2014; Hill et al., 2017a). One group of rough-toothed dolphins was sighted in 2014, but none were encountered in 2015, 2016, or 2017 (Hill et al., 2017a; Hill et al., 2018a).

3.4.1.29.3 Population and Abundance

During the 2007 systematic line-transect survey of the Study Area, there was only one on-effort sighting of rough-toothed dolphin that was used to derive an abundance estimate of 166 animals (CV = 0.892) (Fulling et al., 2011). Given the very limited sample size (a single sighting), this estimate is considered highly uncertain. 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 off Rota in Sasanhayan Bay (Jefferson et al., 2006).

3.4.1.29.4 Predator-Prey Interactions

Rough-toothed dolphin prey includes fish and cephalopods. They are known to feed on large fish species, such as mahi mahi (Miyazaki & Perrin, 1994; Pitman & Stinchcomb, 2002), and have been observed feeding during the day on near-surface fishes, including flying fishes (Gannier & West, 2005). They may also prey on reef fish, as Perkins and Miller (1983) noted that parts of reef fish had been found in the stomachs of stranded rough-toothed dolphins in Hawaii, although the stomach contents of a stranded animal may not be representative of the species.

3.4.1.29.5 Species-Specific Threats

There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in Hawaii. In Hawaii from 2010 to 2014, two rough-toothed dolphins were observed injured during deep-set and shallow-set fisheries in the Exclusive Economic Zone (Bradford & Forney, 2017). Given the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

Although this species has not been documented as prey by other species, it may be subject to predation from killer whales.

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

3.4.1.30.1 Status and Management

Short-finned pilot whale is not listed under the ESA. The stock structure for short-finned pilot whales remains uncertain in the western Pacific, and short-finned pilot whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d). With the exception of the U.S. West Coast, NMFS recognizes a single stock of short-finned pilot whales in the Pacific in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.30.2 Geographic Range and Distribution

In the 2007 survey of the Mariana Islands, short-finned pilot whales were encountered five times in groups ranging in size from 5 to 43 animals (Fulling et al., 2011). During the 2010 NMFS survey there was a single sighting of 23 short-finned pilot whales in the northern portion of the Study Area (Oleson & Hill, 2010a). Closer to the islands, there have been numerous incidental sightings of short-finned pilot whales occurring between 1977 and 2013 (Uyeyama, 2014). During the Navy-funded 2010–2017 small boat surveys in the Mariana Islands, short-finned pilot whale groups were encountered on 16 occasions in a median depth of approximately 700 m and median approximate distance from shore of 5 km, including one pod of 35 individuals off Marpi Reef north of Saipan (Hill et al., 2014; Hill et al., 2017a; Hill et al., 2018a). Satellite tag locations from one short-finned pilot whale in 2016 appeared to indicate a position inside the mouth of Apra Harbor (there were no prior or subsequent positions on that day) (Hill et al., 2017a). However, it should be considered uncertain if the animal was in Apra Harbor, due to the limited precision (error range) of even high-quality Argos satellite fixes, and in particular with regard to reduced longitudinal precision, given the Argos satellites are in polar orbits (Boyd & Brightsmith, 2013; Vincent et al., 2002). Based on the locations from the 2013 to 2016 satellite tagged individuals in May-August timeframe, the combined data has suggested that the northwest side of Guam is a frequently used area for pilot whales during that time of the year (Hill et al., 2017a).

3.4.1.30.3 Population and Abundance

The estimated abundance for short-finned pilot whales in the Study Area is 909 (CV = 0.677), based on sighting data from the 2007 systematic survey of the Mariana Islands (Fulling et al., 2011). Genetic samples taken during small boat surveys between 2010 and 2014 found evidence of genetic differentiation for short-finned pilot whales between the Mariana Islands, although they possess haplotypes also common in the South Pacific, North Atlantic, Indian Ocean, and off of southern Japan (Martien et al., 2014b).

3.4.1.30.4 Predator-Prey Interactions

Pilot whales feed primarily on squid but also take fish (Bernard & Reilly, 1999). They are generally well adapted to feeding on squid (Jefferson et al., 2015; Werth, 2006a, 2006b). Analysis of satellite tagging data from pilot whales in Hawaii correlated with certain environmental parameters, suggesting that the deep mesopelagic boundary community serves as prey for these whales (Abecassis et al., 2015).

Pilot whales are not generally known to prey on other marine mammals, but records from the eastern tropical Pacific suggest that the short-finned pilot whale does occasionally chase and attack, and may eat, dolphins during fishery operations (Olson, 2009; Perryman & Foster, 1980).

3.4.1.30.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least two products contained short-finned pilot whale meat (Baker et al., 2006a).

This species is not known to have any predators (Weller, 2009), although it may be subject to predation by killer whales.

3.4.1.31 Sperm Whale (*Physeter macrocephalus*)

3.4.1.31.1 Status and Management

The sperm whale is listed as endangered under the ESA, but there is no designated critical habitat for this species. The stock structure for sperm whales remains uncertain in the Pacific (Mesnick et al., 2011; Mizroch & Rice, 2013; National Marine Fisheries Service, 2015a), and sperm whales in the Study Area have not been assigned to a stock in the current Pacific SAR (Carretta et al., 2017c; Carretta et al., 2017d). Except for waters off the U.S. West Coast, NMFS recognizes two stocks of sperm whales, one in the central Pacific (in Hawaiian waters) and one in the North Pacific (in Alaskan waters) (Carretta et al., 2017c; Carretta et al., 2017d; Muto et al., 2017a; Muto et al., 2017b).

3.4.1.31.2 Geographic Range and Distribution

Based on whaling data and discovery tag movement data for the North Pacific, it has been argued that the distribution of sperm whales encompasses the entire Pacific Ocean basin, with concentrations in the arctic and subtropical areas (Ilyashenko et al., 2014; Mizroch & Rice, 2013). The Study Area is south of the locations where the majority of sperm whales were encountered during whaling (Mizroch & Rice, 2013; Townsend, 1935), although during a 1972 survey of the Ogasawara and Mariana Island regions two large groups totaling 90 sperm whales were reported (Masaki, 1972). Sperm whales have been routinely sighted in the Study Area and detected in acoustic monitoring records. Acoustic recordings in August 2013 at Pagan Island indicated the presence of sperm whales within 20 NM of the island (Tetra Tech Inc., 2014). Although it has been reported that sperm whales are generally found far offshore in deep water (Mizroch & Rice, 2013), sightings in the Study Area have included animals close to shore in relatively shallow water as well as in areas near steep bathymetric relief (Fulling et al., 2011; Hill et al., 2017a; Uyeyama, 2014). A total of 23 sperm whale sightings and 93 acoustic encounters were made during the 2007 survey in water depths between approximately 400 and 1,000 m depth (Fulling et al., 2011; Yack et al., 2016). There were three encounters with sperm whales during the NMFS 2015 cetacean survey of the Mariana Islands (Hill et al., 2018b; Oleson, 2017). During the Navy-funded 2010–2018 small boat surveys in the Mariana Islands, six sperm whales were encountered on three occasions in a median depth of approximately 1,200 m and median approximate distance from shore of 12 km (Hill et al., 2017a; Hill et al., 2018b). Vocalizations from sperm whales were also detected on 20 occasions to the east and south of Guam by passive acoustic recorders during an underwater glider survey in 2014 (Klinck et al., 2016b).

3.4.1.31.3 Population and Abundance

It is assumed the Pacific population is still recovering, given whaling by the Soviet Union from 1948 to 1979 in the North Pacific took 157,680 sperm whales (Ilyashenko et al., 2014). NMFS has reported that for the Pacific Ocean,[4] the population is estimated between 26,300 and 32,100 for the North Pacific and between 14,800 and 34,600 for the eastern tropical Pacific, while the population of the Hawaii Stock is estimated between 2,539 and 3,354 (National Marine Fisheries Service, 2015a). NMFS has not explicitly stated if the western North Pacific and the Mariana Islands are included in the range for the population of sperm whales considered the North Pacific Stock (Muto et al., 2017a; Muto et al., 2017b; National Marine Fisheries Service, 2015a), although that may be the most logical assignment for those animals in the Study Area. The most recent Alaska SAR provides that there is no current abundance data available for sperm whale of the North Pacific Stock (Muto et al., 2017a; Muto et al., 2017b).

During the 2007 systematic line-transect survey of the Mariana Islands, 11 on-effort sperm whale sightings were used to derive an abundance estimate of 705 animals (CV = 0.604) for the Study Area (Fulling et al., 2011). Passive acoustic monitoring was also conducted during the 2007 survey, and 93 acoustic encounters from vocalizing sperm whales were used to develop a habitat-based density model for this species (Yack et al., 2016). The model provided spatially explicit density estimates for the Study Area, and daily model predictions indicated that sperm whale abundance varied temporally over the period of the 2007 survey (January 15 to April 10). Average Study Area abundance derived from the habitat model was similar to the line-transect estimate based on visual sightings; 700 animals (CV = 0.436) based on a model using sounds typically produced by mature males, females, and juveniles (i.e., “regular clicks”), and 637 animals (CV = 0.447) based on a model using both the regular clicks and “slow clicks” that are only produced by mature males (Yack et al., 2016).

3.4.1.31.4 Predator-Prey Interactions

Sperm whales are known to occur in groups for both predator defense and foraging purposes. 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; Baird, 2009b; Palacios & Mate, 1996; Pitman et al., 2001).

3.4.1.31.5 Species-Specific Threats

Sperm whales are susceptible to injury or mortality from vessel strike (Bradford & Lyman, 2015; Carretta et al., 2016b; Carretta et al., 2017c; Fulling et al., 2017). Sperm whales in the Pacific have been documented as susceptible to entanglement and other interactions with fishing gear (Bradford & Lyman, 2015; Carretta et al., 2016b; Carretta et al., 2017c; Helker et al., 2017). Sperm whales have also been documented as having ingested marine debris, resulting in mortality (Garibaldi & Podesta, 2014; Jacobsen et al., 2010), and as with all most marine mammals, are susceptible to disease (West et al., 2015).

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[4] The “Pacific Ocean” estimates provided did not address or otherwise specifically include the western Pacific Ocean that would include the Study Area.

3.4.1.32 Spinner Dolphin (*Stenella longirostris*)

3.4.1.32.1 Status and Management

The spinner dolphin is not listed under the ESA. The stock structure for spinner dolphins remains uncertain in the western Pacific, and spinner dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d). NMFS recognizes seven stocks of island- or atoll-associated spinner dolphin populations in the Pacific in Hawaii and American Samoa waters (Carretta et al., 2017c; Carretta et al., 2017d), which are all at locations well to the east of the Study Area.

3.4.1.32.2 Geographic Range and Distribution

Spinner dolphins traveling among the Mariana Islands chain are expected to occur throughout the Mariana Islands, having been observed from Uracas in the north to Guam in the south (Fulling et al., 2011; Hill et al., 2017a; Jefferson et al., 2006; Oleson, 2017; Oleson & Hill, 2010b; Tetra Tech Inc., 2014; Trianni & Kessler, 2002; Uyeyama, 2014; Vogt, 2008). Spinner dolphins have been the most frequently encountered species during small boat reconnaissance surveys conducted in the nearshore waters of the Mariana Islands since 2010 but were uncommon offshore (Fulling et al., 2011; HDR, 2011a; HDR EOC, 2012; Hill et al., 2013a; Hill et al., 2014; Hill et al., 2015b; Hill et al., 2016b; Hill et al., 2017a; Hill et al., 2018a; Ligon et al., 2011; Oleson, 2017; Oleson & Hill, 2010b). Previously reported spinner dolphin high-use areas nearshore 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). More recently, high-use areas have included Agat Bay; the Merizo channel, tucked into the several small remote bays between Merizo and Facpi Point; Piti Bay; Hagatna; Tumon Bay; and Pugua Point (Ligon et al., 2011). There have been no documented sightings within Apra Harbor. The locations where spinner dolphins have been documented resting in Agat Bay have been considered for geographic mitigation, as detailed in Appendix I (Geographic Mitigation Assessment).

During the Navy-funded 2010–2017 small boat surveys in the Mariana Islands, 129 spinner dolphins have been encountered on 15 occasions in a median depth of approximately 20 m and median approximate distance from shore of 1 km (Hill et al., 2017a; Hill et al., 2018a). During a survey in August 2013 at Pagan Island, spinner dolphins calves and juveniles were encountered; although sighting rates were low relative to other island areas, re-sightings of four individual spinner dolphins on subsequent days were suggested to be consistent with residency patterns seen elsewhere (Tetra Tech Inc., 2014), which would be similar to behaviors seen in Hawaii (Heenehan et al., 2017b; Lammers, 2004; Marten & Psarakos, 1999; Norris et al., 1994; Tyne et al., 2015; Tyne et al., 2017).

3.4.1.32.3 Population and Abundance

Spinner dolphins were sighted only once during the 2007 broad area line-transect survey of the Mariana Islands (Fulling et al., 2011). As noted previously, spinner dolphins have been the most commonly encountered species in nearshore waters less than 1 km from shore and have been encountered in group sizes of up to 124 individuals in a pod (HDR, 2011a; HDR EOC, 2012; Hill et al., 2011; Hill et al., 2013a; Hill et al., 2013b; Hill et al., 2014; Hill et al., 2015b; Hill et al., 2016b; Hill et al., 2017a; Hill et al., 2018a; Ligon et al., 2011; Oleson & Hill, 2010b). Genetic samples (n = 93) from spinner dolphins encountered during small boat surveys off Guam and Saipan between 2010 and 2014 suggest the population has high haplotypic diversity similar to that observed in the Society Islands of French Polynesia and that spinner dolphins around the Mariana Islands are much less isolated than those around the Hawaiian Islands (Martien et al., 2014b).

3.4.1.32.4 Predator-Prey Interactions

Spinner dolphins feed primarily on small mid-water fishes, squids, and shrimp, and dive to at least 200–300 m (Benoit-Bird & Au, 2003; Perrin & Gilpatrick, 1994). They forage primarily at night, when the mid-water community migrates toward the surface and the shore (Benoit-Bird et al., 2001; Benoit-Bird, 2004; Benoit-Bird & Au, 2009; Tyne et al., 2017). Spinner dolphins track the horizontal and vertical migrations of their prey (Benoit-Bird & Au, 2003), allowing for foraging efficiencies (Benoit-Bird et al., 2001; Benoit-Bird & Au, 2003, 2004; Benoit-Bird & Au, 2009). Foraging behavior has also been linked to lunar phases in scattering layers off of Hawaii (Benoit-Bird & Au, 2004).

3.4.1.32.5 Species-Specific Threats

There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in Hawaii. In Hawaiian waters from 2008 to 2012 there were three observed serious injuries (leading to death) to spinner dolphins (Bradford & Lyman, 2015). Two of these injuries were fishing related, and one involved marine debris preventing the individual's mouth from opening. Given the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

Spinner dolphins are also at risk if ecotourism and whale-watching activities result in chronic disturbance in their resting habitats (Courbis & Timmel, 2008; Heenehan et al., 2016; Heenehan et al., 2017a; Tyne et al., 2014; Tyne, 2015; Tyne et al., 2015; Tyne et al., 2017; Tyne et al., 2018). Courbis (2008) found changes in spinner dolphin aerial behaviors and suggested it was likely that vessel and swimmer activity was at least synergistically involved in causing these changes, but whether the behavioral changes affected the survival and fitness of spinner dolphins remains unknown.

Spinner dolphins have stranded at Saipan (Trianni & Kessler, 2002). Spinner dolphins may be preyed on by sharks, killer whales, pygmy killer whales, and short-finned pilot whales (Perrin, 2009a).

3.4.1.33 Striped Dolphin (*Stenella coeruleoalba*)

3.4.1.33.1 Status and Management

The striped dolphin is not listed under the ESA. The stock structure for striped dolphins remains uncertain in the western Pacific, and striped dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d). Other than along the U.S. West Coast, NMFS recognizes only a single stock of striped dolphins that is present within the 200-mile Exclusive Economic Zone defining Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d).

3.4.1.33.2 Geographic Range and Distribution

Striped dolphins are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In the eastern tropical Pacific, striped dolphins inhabit areas with large seasonal changes in surface temperature and thermocline depth, as well as seasonal upwelling (Au & Perryman, 1985; Reilly, 1990). The observed northern limits for the species are the Sea of Japan off Hokkaido, off Washington State in the eastern Pacific, or roughly along 40° N latitude across the western and central Pacific (Reeves et al., 2002).

Prior to the 2007 survey of the Study Area (Fulling et al., 2011), striped dolphins were only known to occur in the area from two strandings, one recorded in July 1985 (Eldredge, 1991, 2003) and a second in 1993 off Saipan (Trianni & Tenorio, 2012). However, striped dolphins were sighted throughout the Study Area during the 2007 survey (Fulling et al., 2011). There was at least one sighting over the Mariana Trench, southeast of Saipan. Group sizes ranged from 7 to 44 individuals, and several sightings included calves. In early April 2010, during an oceanographic survey of waters in Micronesia and the Commonwealth of the Northern Mariana Islands, there were two striped dolphin sightings (pod sizes of 6 and 12) in waters to the south of Guam (Oleson & Hill, 2010a). Striped dolphins have not been reported during more recent non-systematic surveys in the Study Area involving small boats operating close to shore (Hill et al., 2011; Hill et al., 2013a; Hill et al., 2014; Hill et al., 2015b; Hill et al., 2017a; Hill et al., 2018a).

3.4.1.33.3 Population and Abundance

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

3.4.1.33.4 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 (lanternfishes), suggesting that striped dolphins may be feeding at great depths, possibly diving to 200–700 m, and may feed at night in order to take advantage of the deep scattering layer's diurnal vertical movements, including small mid-water fishes and squids (Archer & Perrin, 1999; Perrin et al., 1994b). This species has been documented to be preyed upon by sharks (Ross & Bass, 1971). It may also be subject to predation by killer whales.

3.4.1.33.5 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., 2017c; Carretta et al., 2017d). There are no specific fisheries interactions or other information on species-specific threats available for this species in the Study Area. Given the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

3.4.2 Environmental Consequences

Under the Proposed Action for this SEIS/OEIS, there have been some modifications to the quantity and type of acoustic stressors under the two action alternatives. Additionally, there is one new sub-stressor (high-energy lasers) being analyzed because of the potential to affect marine species, as detailed in Section 3.0.4.3.2.2 (High-Energy Lasers).

In the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015a), the Navy considered all potential stressors associated with ongoing military readiness in the Mariana Islands and then analyzed their potential impacts on marine mammals in the Study Area. In addition, NMFS also reviewed the Navy's analysis and detailed their findings with regard to requirements under the MMPA (80 FR 46112) and pursuant to the ESA for the Navy's Proposed Action in the Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015b).

In general, there have been no substantial changes to the activities analyzed as the Proposed Action the 2015 MITT Final EIS/OEIS that would change the conclusions reached regarding populations of marine mammals in the Study Area. Use of acoustic stressors (sonar and other transducers) and use of explosives have occurred in the Mariana Islands for decades and were last authorized by the 2015 completion of the MITT Record of Decision, MMPA Authorization, and ESA Biological Opinion. There have been no known impacts on populations of marine mammals or adverse effects to ESA-listed marine mammal species that were not otherwise previously analyzed or accounted for in the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015b), the NMFS MMPA Authorization (80 FR 46112), or the NMFS Biological Opinion pursuant to ESA (National Oceanic and Atmospheric Administration, 2015a) with regard to acoustic or explosive stressors.

In this SEIS/OEIS, the Navy has reviewed the analysis of impacts from these ongoing activities and additionally analyzed the new or changing training and testing activities as projected into the reasonably foreseeable future. The projected future actions are based on evolving operational requirements, including those associated with any anticipated new platforms or systems not previously analyzed. The Navy has compiled, thoroughly reviewed, and incorporated the best available emergent marine mammal science since 2015 that is relevant to the analysis of environmental impacts from the proposed activities as presented in the 2015 MITT Final EIS/OEIS. Where there has been no substantive or otherwise meaningful change in the action, science, or regulations, the Navy will rely on the 2015 MITT Final EIS/OEIS analysis. Where there has been substantive change in the action, science, or regulations, the information and analysis provided in this SEIS/OEIS will supplement the 2015 MITT Final EIS/OEIS to support environmental compliance with applicable environmental statutes for marine mammals (the MMPA and ESA).

The 2015 MITT Final EIS/OEIS considered all training and testing activities proposed to occur in the Study Area that may have the potential to result in the MMPA-defined take of marine mammals or to affect ESA-listed marine mammal species. The stressors applicable to marine mammals in the Study Area for this SEIS/OEIS include a new stressor (high-energy laser) and the same stressors considered in the 2015 MITT Final EIS/OEIS:

- **Acoustic** (sonar and other transducers, vessel noise, aircraft noise, weapon noise)
- **Explosives** (in-air explosions and in-water explosions)
- **Energy** (in-water electromagnetic devices, high-energy lasers)
- **Physical disturbance and strike** (vessels and in-water devices, military expended materials, seafloor devices)
- **Entanglement** (wires and cables, decelerators/parachutes)
- **Ingestion** (military expended materials – munitions, military expended materials other than munitions)
- **Secondary** (impacts on habitat, impacts on prey availability)

This section of this SEIS/OEIS evaluates how and to what degree potential impacts on marine mammals from stressors described in Section 3.0 (Introduction) may have changed since the analysis presented in the 2015 MITT Final EIS/OEIS was completed. Table 2.5-1 and Table 2.5-2 in Chapter 2 (Description of Proposed Action and Alternatives) list the proposed training and testing activities and include the number of times each activity would be conducted annually and the locations within the Study Area where the activity would typically occur under each alternative. The tables also present the same information for activities described in the 2015 MITT Final EIS/OEIS so that the proposed levels of training and testing under this SEIS/OEIS can be easily compared. The analysis in this SEIS/OEIS includes consideration of the Navy's standard operating procedures and mitigation that the Navy will implement to avoid or reduce potential impacts on marine mammals from acoustic, explosive, and physical disturbance and strike stressors. Mitigation for marine mammals will be coordinated with NMFS through the MMPA and ESA consultation processes, and is detailed in Chapter 5 (Mitigation) and Appendix I (Geographic Mitigation Assessment) of this SEIS/OEIS.

In 2015, the Navy and NMFS determined that within the Study Area only acoustic stressors and explosive stressors could potentially result in harassment and/or the incidental taking of marine mammals from Navy training and testing activities (80 FR 46112) and that none of the other stressors would result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b).

There has been no emergent science that would necessitate changes to conclusions reached by Navy or NMFS (as a cooperating agency) in the 2015 MITT Final EIS/OEIS regarding those other dismissed stressors as having a negligible or discountable impact on marine mammal populations or species. As detailed in Chapter 2 (Description of Proposed Action and Alternatives) of this SEIS/OEIS, there are no changes to proposed training and testing activities that would necessitate re-analysis of any of the activities associated with those stressors for which NMFS has previously determined did not rise to the level of a take under MMPA. The analysis presented in this section of the SEIS/OEIS also considers standard operating procedures, which are discussed in Section 2.3.3 (Standard Operating Procedures) of this Draft SEIS/OEIS, and mitigation measures that are described in Chapter 5 (Mitigation). The Navy would implement these measures to avoid or reduce potential impacts on marine mammals from stressors associated with the proposed training and testing activities. Mitigation for marine mammals will be coordinated with NMFS through the ESA consultation process. In addition, in the Draft SEIS/OEIS the Navy has developed Appendix I (Geographic Mitigation Assessment), which details consideration of specific mitigation areas identified by the public during the scoping process. In short, Appendix I contains the background information for each area being considered and lays out the methodology used by the Navy in its scientific and operational analysis for assessing and developing proposed geographic mitigation areas within the MITT Study Area to further avoid or reduce potential impacts on marine mammals in areas that may be of particular biological importance.

As presented in Section 3.0 (Introduction), since completion of the 2015 MITT Final EIS/OEIS there have been refinements made in the modeling of potential impacts from sonar and other transducers and in-water explosives. These changes have been incorporated into the re-analysis of acoustic and explosive stressors presented in this SEIS/OEIS. In addition to the new effects criteria, weighting functions, and thresholds for multiple species, new information for marine mammals includes the integration of new marine mammal density data based on new survey data (Bradford et al., 2017) and the integration of data from acoustic monitoring (Norris et al., 2017; Yack et al., 2016).

There have been no changes to the MITT Study Area, existing conditions, species life histories, or any new information available since 2015 that would otherwise substantively change the conclusions[5] presented in the 2015 MITT Final EIS/OEIS. What is new since 2015 are refinements to the Navy Acoustic Effects Model. This SEIS/OEIS, therefore, focuses on a re-analysis of potential impacts on marine mammals from acoustic stressors involving use of sonar and other transducers, and the use of in-water explosives. The following paragraphs provide details on refinements to the Navy's acoustic modeling since 2015. Most important is the information found in Section 3.4.3.4 (Summary of Monitoring and Observations During Navy Activities Since 2015) regarding scientific data gathered on marine mammals in locations where the Navy has been training and testing, which serves as an empirical basis for the marine mammal impact assessment presented in this SEIS/OEIS.

New effects criteria, weighting functions, and thresholds

A detailed description of the Phase III acoustic and explosive criteria and threshold development regarding marine mammals is included in the supporting technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a). In summary, the update to the acoustic impact criteria has largely been predicated on a series of behavioral studies (often sponsored by the U.S. Navy), which have led to a new understanding of how some marine mammals react to sonar and other sound sources (Baird et al., 2017; Crowell et al., 2016; Curé et al., 2016; Dunlop et al., 2016; Friedlaender et al., 2016; Graham et al., 2017; Harris et al., 2018; Henderson et al., 2015a; Kvadsheim et al., 2017; Pirotta et al., 2016; Sabet et al., 2016; Sivle et al., 2015; Southall et al., 2016; Visser et al., 2016). As a result of that new understanding, the previous behavioral response functions for estimating alterations in behavior have been refined to accurately reflect studies undertaken both in the ocean and in well controlled studies done in laboratory settings. Additional studies have also provided information allowing for the refinement of the previous auditory weighting functions (Finneran et al., 2015; Houser et al., 2016; Houser et al., 2017; Kastelein et al., 2015b; Kastelein et al., 2015c; Kastelein et al., 2015d; Kastelein et al., 2016; Kastelein et al., 2017; Mulsow et al., 2015), and has led to a new methodology to predict these functions for each hearing group along with the accompanying hearing loss thresholds. These criteria for estimating hearing loss in marine mammals was largely adopted by NMFS for species within their purview (81 FR 51693) and is used in the analysis for impacts on marine mammals presented in this SEIS/OEIS.

The majority of the changes in the results of the impact analyses presented in this SEIS/OEIS pursuant to requirements of the MMPA arise from changes in the model input; specifically, more accurate marine mammal density data, revised acoustic impact criteria, and more comprehensive computer modeling of predicted effects on marine mammals. Assessment of likely long-term consequences to populations of

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[5] Conclusions in this regard refer to the findings reached by Navy and NMFS on the two previous sets of analyses for the continuation of training and testing in Study Area. NMFS has recently re-considered analysis of Navy training and testing for many of the same for actions elsewhere (83 FR 10954 and 83 FR 29872) and for a third time reaffirmed their earlier conclusions regarding Navy military readiness activities. The Navy and NMFS have found that there would not be significant impacts on populations of marine mammals resulting from the continuation of training and testing. Under ESA, the Proposed Action may affect certain ESA-listed marine mammal species, but were not likely to jeopardize the continued existence of the continued existence of those species.

marine mammals are provided by empirical data gathered from areas where the Navy routinely trains and tests. Substantial Navy-funded marine mammal survey data, monitoring data, and scientific research have been completed since 2007. These empirical data are beginning to provide insight on the qualitative analysis of the actual (as opposed to model predicted numerical) impact on marine mammals resulting from Navy training and testing activities based on observations of marine mammals generally in and around Navy Range Complexes.

The following subsections of this SEIS/OEIS present the potential environmental consequences based on an updated modeling methodology and the scientific observations and investigations made over 12 years of monitoring training and testing activities in the Pacific and elsewhere that are representative of the type of activities proposed in this SEIS/OEIS.

3.4.2.1 Acoustic Stressors

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 sources, 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, 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., 2007b; Southall et al., 2007). Many other factors besides just the received level of sound may affect an animal's reaction, such as the duration of the sound-producing activity, the animal's physical condition, prior experience with the sound, activity at the time of exposure (e.g., feeding, traveling, resting), the context of the exposure (e.g., in a semi-enclosed bay versus open ocean), and proximity to the source of the sound.

The ways in which an acoustic exposure could result in immediate effects or long-term consequences for an animal are explained in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). The following background section discusses what is currently known about acoustic effects to marine mammals. These effects could hypothetically extend from physical injury or trauma to a behavioral or stress response that may or may not be detectable. Injury (physical trauma) can occur to organs or tissues of an animal (Section 3.4.2.1.1.1, Injury). Hearing loss (Section 3.4.2.1.1.2, Hearing Loss) is a noise-induced decrease in hearing sensitivity, which can be either temporary or permanent. Masking (Section 3.4.2.1.1.4, Masking) can occur when the perception of a biologically important sound (i.e., signal) is interfered with by a second sound (i.e., noise). Physiological stress (Section 3.4.2.1.1.3, Physiological Stress) is an adaptive process that helps an animal cope with changing conditions; however, too much stress can potentially result in additional physiological effects. Behavioral response (Section 3.4.2.1.1.5, Behavioral Reactions) ranges from brief distractions to avoidance of a sound source to prolonged flight. Extreme behavioral or physiological responses can lead to stranding (Section 3.4.2.1.1.6, Stranding). Long-term consequences (Section 3.4.2.1.1.7, Long-Term Consequences) are those impacts, or accumulation of impacts, that can result in decreases in individual fitness or population changes. To avoid or reduce potential impacts to the maximum extent practicable, the Navy will implement marine mammal mitigation measures during applicable training and testing activities that generate acoustic stressors (see Chapter 5, Mitigation; and Appendix I, Geographic Mitigation Assessment).

The Navy will rely on the previous 2015 MITT Final EIS/OEIS for the analysis of vessel noise, aircraft noise, and weapon noise; new applicable and emergent science in regard to these sub-stressors is presented in the sections that follow. Due to new acoustic impact criteria, marine mammal densities, and revisions to the acoustic effects model, the analysis provided in Section 3.4.2.1.2 (Impacts from Sonar and Other Transducer Stressors) of this SEIS/OEIS supplants the 2015 MITT Final EIS/OEIS for marine mammals and changes estimated impacts for some species since the 2015 MITT Final EIS/OEIS.

3.4.2.1.1 Background

3.4.2.1.1.1 Injury

Injury (i.e., physical trauma) refers to the effects on the tissues or organs of an animal due to exposure to pressure waves. Injury due to exposure to non-explosive acoustic stressors such as sonar is discussed below. Moderate- to low-level sound sources, including vessel and aircraft noise, would not cause any injury. Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on injury (i.e., physical trauma) and the framework used to analyze this potential impact.

Several mechanisms of acoustically induced tissue damage (non-auditory) have been proposed and are discussed below.

Injury Due to Sonar-Induced Acoustic Resonance

An object exposed to its resonant frequency will tend to amplify its vibration at that frequency, a phenomenon called acoustic resonance. Acoustic resonance has been proposed as a mechanism by which a sonar or sources with similar operating characteristics could damage tissues of marine mammals. In 2002, NMFS convened a panel of government and private scientists to investigate the potential for acoustic resonance to occur in marine mammals (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. The conclusions of the group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding in 2000. The frequency at which resonance was predicted to occur in the animals' lungs was 50 Hz, well below the frequencies used 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 unrealistic scenario in which air volumes would be undamped (unrestrained) by surrounding tissues and the amplitude of the resonant response would be greatest. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance would not occur under realistic conditions during training and testing activities, and this type of impact is not considered further in this analysis.

Nitrogen Decompression

Marine mammals are thought to deal with nitrogen loads in their blood and other tissues, caused by gas exchange from the lungs under conditions of high ambient pressure during diving, through anatomical, behavioral, and physiological adaptations (Hooker et al., 2012).

Although not a direct injury, variations in marine mammal diving behavior or avoidance responses have been hypothesized to result in nitrogen off-gassing in super-saturated tissues, possibly to the point of deleterious vascular and tissue bubble formation (Hooker et al., 2012; Jepson et al., 2003; Saunders et al., 2008) with resulting symptoms similar to decompression sickness (also known as "the bends"). The process has been under debate in the scientific community (Hooker et al., 2012; Saunders et al., 2008), although analyses of bycaught and drowned animals have demonstrated that nitrogen bubble formation can occur in animals that no longer exchange gas with the lungs (drowned) and which are brought to the surface where tissues become supersaturated with nitrogen due to the reduction in hydrostatic pressure (Bernaldo de Quiros et al., 2013b; Moore et al., 2009). Deep-diving whales, such as beaked whales, have been predicted to have higher nitrogen loads in body tissues for certain modeled changes in dive behavior, which might make them more susceptible to decompression (Fahlman et al., 2014b; Fernandez et al., 2005; Hooker et al., 2012; Jepson et al., 2003).

Researchers have examined how dive behavior affects tissue supersaturation conditions that could put an animal at risk of gas bubble embolism. An early hypothesis was 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 (Fernandez et al., 2005; Jepson et al., 2003). However, 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 & Tyack, 2007). Instead, emboli observed in animals exposed to mid-frequency active sonar (Fernandez et al., 2005; Jepson et al., 2003) could stem from a behavioral response that involves repeated dives, shallower than the depth of lung collapse (Aguilar de Soto et al., 2006; Hooker et al., 2012; Tyack et al., 2006; Zimmer & Tyack, 2007). Longer times spent diving at mid-depths above lung collapse would allow gas exchange from the lungs to continue under high hydrostatic pressure conditions, increasing potential for supersaturation; below the depth of lung collapse, gas exchange from the lungs to the blood would likely not occur (Fahlman et al., 2014b). To examine the potential for gas bubble formation, a bottlenose dolphin was trained to dive repetitively to depths shallower than lung collapse 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., 2009). To estimate risk of decompression sickness, Kvadsheim et al. (2012) modeled gas exchange in the tissues of sperm, pilot, killer, and beaked whales based on actual dive behavior during exposure to sonar in the wild. Results indicated that venous supersaturation was within the normal range for these species, which have naturally high levels of nitrogen loading.

Still, little is known about respiratory physiology of deep-diving breath-hold animals. Costidis and Rommel (2016) suggest that gas exchange may continue to occur across the tissues of air-filled sinuses in deep-diving odontocetes below the depth of lung collapse, if hydrostatic pressures are high enough to drive gas exchange across into non-capillary veins, contributing to tissue gas loads. Researchers have also considered the role of carbon dioxide accumulation produced during periods of high activity by an animal, theorizing that accumulating carbon dioxide, which cannot be removed by gas exchange below the depth of lung collapse, may facilitate the formation of bubbles in nitrogen-saturated tissues (Bernaldo de Quiros et al., 2012; Fahlman et al., 2014b). Garcia Parraga et al. (2018) suggest that diving marine mammals have physiological and anatomical adaptations to control gas uptake above the depth of lung collapse, favoring oxygen uptake while minimizing nitrogen uptake. Under the hypothesis of Garcia Parraga et al. (2018), elevated activity due to a strong evasive response could lead to increased uptake of nitrogen, resulting in an increased risk of nitrogen decompression.

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 (i.e., tissues that take longer to give off nitrogen, such as fat and bone lipid) to the point that they are supersaturated when the animals are at the surface (Fahlman et al., 2014b; Hooker et al., 2009; Saunders et al., 2008). The presence of osteonecrosis (bone death due to reduced blood flow) in deep-diving sperm whales has been offered as evidence of chronic supersaturation (Moore & Early, 2004). 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 in these tissues has been demonstrated in marine mammals drowned at depth as fisheries bycatch and brought to the surface (Moore et al., 2009). For beaked whale strandings associated with sonar use, one theory is that observed bubble formation might be caused by long periods of compromised blood flow caused by the stranding itself (which reduces ability to remove nitrogen from tissues) following rapid ascent dive behavior that does not allow for typical management of nitrogen in supersaturated, long-halftime tissues (Houser et al., 2009).

A fat embolic syndrome (out-of-place fat particles, typically in the bloodstream) 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. Although rare, similar findings have been found in the Risso's dolphin, another deep-diving species, but with presumably non-anthropogenic causes (Fernandez et al., 2017).

Dennison et al. (2012) reported on investigations of dolphins stranded in 2009–2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of the 22 live-stranded dolphins and in the livers of two of the 22. The authors postulated that stranded animals were unable to recompress by diving, and thus retained bubbles that would have otherwise re-absorbed in animals that continued to dive. The researchers concluded that the minor bubble formation observed could be tolerated since the majority of stranded dolphins released did not re-strand.

The appearance of extensive bubble and fat emboli in beaked whales was unique to a small number of strandings associated with certain high-intensity sonar events; the phenomenon has not been observed to the same degree in other stranded marine mammals, including other beaked whale strandings not associated with sonar use. It is uncertain as to whether there is some more easily triggered mechanism for this phenomenon specific to beaked whales or whether the phenomenon occurs only following rapidly occurring stranding events (i.e., when whales are not capable of sufficiently decompressing). Nevertheless, based on the rarity of observations of bubble pathology, the potential for nitrogen decompression sickness, or "the bends," is considered discountable.

Acoustically Induced Bubble Formation Due to Sonars

A suggested cause of injury to marine mammals is rectified diffusion (Crum & Mao, 1996), the process of increasing the size of a microscopic gas 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, microscopic bubbles assumed to exist in the tissues of marine mammals may experience one of three things: (1) bubbles grow to the extent they become emboli or cause localized tissue trauma, (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.

Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. As discussed above, repetitive diving by marine mammals can cause the blood and some tissues to become supersaturated (Ridgway & Howard, 1979). The dive patterns of some marine mammals (e.g., beaked whales) are predicted to induce greater supersaturation (Houser et al., 2001). 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.

It is unlikely that the short duration of sonar pulses 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 supersaturated tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough time for bubbles to become a problematic size. The phenomena of bubble growth due to a destabilizing exposure was shown by Crum et al. (2005) by exposing highly supersaturated ex vivo bovine tissues to a 37 kHz source at 214 dB re 1 µPa. Although bubble growth occurred under the extreme conditions created for the study, these conditions would not exist in the wild because the levels of tissue supersaturation in the study (as high as 400–700 percent) are substantially higher than model predictions for marine mammals (Fahlman et al., 2009; Fahlman et al., 2014b; Houser et al., 2001; Saunders et al., 2008), and such high exposure level would only occur in very close proximity to the most powerful sonars. It is improbable that this mechanism is responsible for stranding events or traumas associated with beaked whale strandings.

There has been considerable disagreement among scientists as to the likelihood of this phenomenon (Evans & Miller, 2003; Piantadosi & Thalmann, 2004). Although it has been argued that traumas from 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 (Bernaldo de Quiros et al., 2012; Bernaldo de Quiros et al., 2013a; Bernaldo de Quiros et al., 2013b; Dennison et al., 2012; Moore et al., 2009).

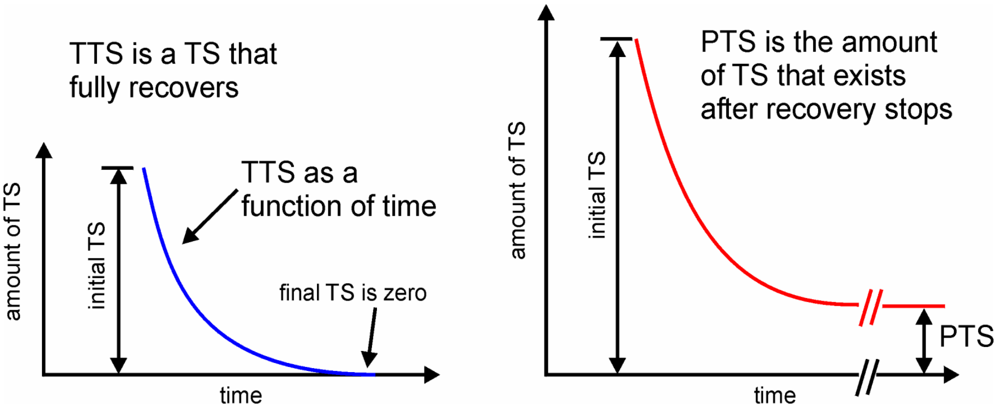
3.4.2.1.1.2 Hearing Loss

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received sound pressure level, temporal pattern, and duration. The frequencies affected by hearing loss will vary depending on the frequency of the fatiguing noise, with frequencies at and above the noise frequency most strongly affected. The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies.

Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on hearing loss and the framework used to analyze this potential impact. Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative.

Hearing loss is typically quantified in terms of threshold shift (TS)—the amount (in dB) that hearing thresholds at one or more specified frequencies are elevated, compared to their pre-exposure values, at some specific time after the noise exposure. The amount of TS measured usually decreases with increasing recovery time—the amount of time that has elapsed since a noise exposure. If the TS eventually returns to zero (i.e., the hearing threshold returns to the pre-exposure value), the threshold shift is called a temporary threshold shift (TTS). If the TS does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining TS is called a permanent threshold shift (PTS). Figure 3.4-2 shows two hypothetical TSs: one that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. By definition, TTS is a function of the recovery time, therefore comparing the severity of noise exposures based on the amount of induced TTS can only be done if the recovery times are also taken into account. For example, a 20 dB TTS measured 24 hours post-exposure indicates a more hazardous exposure than one producing 20 dB of TTS measured only two minutes after exposure; if the TTS is 20 dB after 24 hours, the TTS measured after two minutes would have likely been much higher. Conversely, if 20 dB of TTS was measured after two minutes, the TTS measured after 24 hours would likely have been much smaller.

Studies have revealed that intense noise exposures may also cause auditory system injury that does not result in PTS (i.e., hearing thresholds return to normal after the exposure, but there is injury nonetheless). Kujawa and Liberman (2009) found that noise exposures sufficient to produce a TTS of 40 dB, measured 24 hours post-exposure using electro-physiological methods, resulted in acute loss of nerve terminals and delayed degeneration of the cochlear nerve in mice. Lin et al. (2011) found a similar result in guinea pigs, that a TTS in auditory evoked potential of up to approximately 50 dB, measured 24 hours post-exposure, resulted in neural degeneration. These studies demonstrate that PTS should not be used as the sole indicator of auditory injury, since exposures producing high levels of TTS (40 to 50 dB measured 24 hours after exposure)—but no PTS—may result in auditory injury.



Notes: TTS = Temporary Threshold Shift, TS = Threshold Shift, PTS = Permanent Threshold Shift

Figure 3.4-2: Two Hypothetical Threshold Shifts

There are no simple functional relationships between TTS and the occurrence of PTS or other auditory injury (e.g., neural degeneration). However, TTS and PTS are, by definition, mutually exclusive. An exposure that produces TTS cannot also produce PTS in the same individual; conversely, if an initial threshold shift only partially recovers, resulting in some amount of PTS, the difference between the initial TS and the PTS is not called TTS. As TTS increases, the likelihood that additional exposure SPL or duration will result in PTS or other injury also increases. Exposure thresholds for the occurrence of PTS or other auditory injury can therefore be defined based on a specific amount of TTS; that is, although an exposure has been shown to produce only TTS, we assume that any additional exposure may result in some PTS or other injury. The specific upper limit of TTS is based on experimental data showing amounts of TTS that have not resulted in PTS or injury. In other words, we do not need to know the exact functional relationship between TTS and PTS or other injury, we only need to know the upper limit for TTS before some PTS or injury is possible.

A variety of human and terrestrial mammal data indicate that threshold shifts up to 40 to 50 dB may be induced without PTS, and that 40 dB is a reasonable upper limit for allowable threshold shift to prevent PTS (e.g., Kryter et al., 1965; Miller et al., 1963; Ward et al., 1958; Ward et al., 1959; Ward, 1960). It is reasonable to assume the same relationship would hold for marine mammals, since there are many similarities between the inner ears of marine and terrestrial mammals, and experiments with marine mammals have revealed similarities to terrestrial mammals for features such as TTS, age-related hearing loss, drug-induced hearing loss, masking, and frequency selectivity (Finneran et al., 2005a; Finneran, 2015; Ketten, 2000). Therefore, we assume that sound exposures sufficient to produce 40 dB of TTS measured approximately four minutes after exposure represent the limit of a non-injurious exposure (i.e., higher-level exposures have the potential to cause auditory injury). Exposures sufficient to produce a TTS of 40 dB, measured approximately four minutes after exposure, therefore represent the threshold for auditory injury. The predicted injury could consist of either hair cell damage/loss resulting in PTS or other auditory injury, such as the delayed neural degeneration identified by Kujawa and Liberman (2009) and Lin et al. (2011) that may not result in PTS.

Numerous studies have directly examined noise-induced hearing loss in marine mammals (see Finneran, 2015). In these studies, hearing thresholds were measured in marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds was then used to determine the amount of TTS at various post-exposure times. The major findings from these studies include the following:

- The method used to test hearing may affect the resulting amount of measured TTS, with neurophysiological measures producing larger amounts of TTS compared to psychophysical measures (Finneran et al., 2007; Finneran, 2015).
- The amount of TTS varies with the hearing test frequency. As the exposure SPL increases, the frequency at which the maximum TTS occurs also increases (Kastelein et al., 2014b). For high-level exposures, the maximum TTS typically occurs one-half to one octave above the exposure frequency (Finneran et al., 2007; Mooney et al., 2009a; Nachtigall et al., 2004; Popov et al., 2011; Popov et al., 2013; Schlundt et al., 2000). The overall spread of TTS from tonal exposures can therefore extend over a large frequency range (i.e., narrowband exposures can produce broadband [greater than one octave] TTS).
- The amount of TTS increases with exposure SPL and duration and is correlated with sound exposure level (SEL), especially if the range of exposure durations is relatively small (Kastak et al., 2007; Kastelein et al., 2014b; Popov et al., 2014). As the exposure duration increases, however, the relationship between TTS and SEL begins to break down. Specifically, duration has a more significant effect on TTS than would be predicted on the basis of SEL alone (Finneran et al., 2010a; Kastak et al., 2005; Mooney et al., 2009a). This means if two exposures have the same SEL but different durations, the exposure with the longer duration (thus lower SPL) will tend to produce more TTS than the exposure with the higher SPL and shorter duration. In most acoustic impact assessments, the scenarios of interest involve shorter duration exposures than the marine mammal experimental data from which impact thresholds are derived; therefore, use of SEL tends to over-estimate the amount of TTS. Despite this, SEL continues to be used in many situations because it is relatively simple, more accurate than SPL alone, and lends itself easily to scenarios involving multiple exposures with different SPL.
- The amount of TTS depends on the exposure frequency. Sounds at low frequencies, well below the region of best sensitivity, are less hazardous than those at higher frequencies, near the region of best sensitivity (Finneran & Schlundt, 2013). The onset of TTS—defined as the exposure level necessary to produce 6 dB of TTS (i.e., clearly above the typical variation in threshold measurements)—also varies with exposure frequency. At low frequencies onset-TTS exposure levels are higher compared to those in the region of best sensitivity.

- TTS can accumulate across multiple exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same SEL (Finneran et al., 2010a; Kastelein et al., 2014b; Kastelein et al., 2015b; Mooney et al., 2009b). This means that TTS predictions based on the total, cumulative SEL will overestimate the amount of TTS from intermittent exposures such as sonars and impulsive sources.
- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic (i.e., increasing exposure does not always increase TTS). The 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., approximately 40 dB) may require several days for recovery. Under many circumstances TTS recovers linearly with the logarithm of time (Finneran et al., 2010a, 2010b; Finneran & Schlundt, 2013; Kastelein et al., 2012a; Kastelein et al., 2012b; Kastelein et al., 2013a; Kastelein et al., 2014b; Kastelein et al., 2014c; Popov et al., 2011; Popov et al., 2013; Popov et al., 2014). This means that for each doubling of recovery time, the amount of TTS will decrease by the same amount (e.g., 6 dB recovery per doubling of time).

Nachtigall et al. (2018) and Finneran (2018) describe the measurements of hearing sensitivity of multiple odontocete species (bottlenose dolphin, harbor porpoise, beluga, and false killer whale) when a relatively loud sound was preceded by a warning sound. These captive animals were shown to reduce hearing sensitivity when warned of an impending intense sound. Based on these experimental observations of captive animals, the authors suggest that wild animals may dampen their hearing during prolonged exposures or if conditioned to anticipate intense sounds. Finneran recommends further investigation of the mechanisms of hearing sensitivity reduction in order to understand the implications for interpretation of some existing temporary threshold shift data obtained from captive animals, notably for considering TTS due to short duration, unpredictable exposures. No modification of analysis of auditory impacts is currently suggested, as the Phase III auditory impact thresholds are based on best available data for both impulsive and non-impulsive exposures to marine mammals.

Due to the higher exposure levels or longer exposure durations required to induce hearing loss, only a few types of human-made sound sources have the potential to cause a threshold shift to a marine mammal in the wild. These include some sonars and other transducers and impulsive sound sources such as air guns and impact pile driving, neither of which will be used in the Study Area.

Threshold Shift due to Sonar and Other Transducers

TTS in mid-frequency cetaceans exposed to non-impulsive sound has been investigated in multiple studies (Finneran et al., 2005b; Finneran et al., 2010b; Finneran & Schlundt, 2013; Mooney et al., 2009a; Mooney et al., 2009b; Nachtigall et al., 2003; Nachtigall et al., 2004; Popov et al., 2013; Popov et al., 2014; Schlundt et al., 2000) from two species, bottlenose dolphins and beluga whales. Two high-frequency cetacean species have been studied for TTS due to non-impulsive sources: the harbor porpoise (Kastelein et al., 2012b) and the finless porpoise (*Neophocaena phocaenoides*) (Popov et al., 2011). TTS from non-impulsive sounds has also been investigated in three pinniped species: harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*), and Northern elephant seal (*Mirounga angustirostris*) (e.g., Kastak et al., 2005; Kastelein et al., 2012a). These data are reviewed in detail in Finneran (2015) as well as the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* technical report (U.S. Department of the Navy, 2017a), and the major findings are summarized above.

3.4.2.1.1.3 Physiological Stress

The growing field of conservation physiology relies in part on the ability to monitor stress hormones in populations of animals, particularly those that are threatened or endangered. The ability to make predictions from stress hormones about impacts on individuals and populations exposed to various forms of stressors, natural and human-caused, relies on understanding the linkages between changes in stress hormones and resulting physiological impacts. At this time, the sound characteristics that correlate with specific stress responses in marine mammals are poorly understood, as are the ultimate consequences due to these changes. Navy-funded efforts are underway to try to improve the understanding of and the ability to predict how stressors ultimately affect marine mammal populations (e.g., King et al., 2015; New et al., 2013a; New et al., 2013b; Pirotta et al., 2015a). With respect to acoustically induced stress, this includes not only determining how and to what degree various types of anthropogenic sound cause stress in marine mammals, but what factors can mitigate those responses. Factors potentially affecting an animal's response to a stressor include the mammal's life history stage, sex, age, reproductive status, overall physiological and behavioral plasticity, and whether they are naïve or experienced with the sound [e.g., prior experience with a stressor may result in a reduced response due to habituation (Finneran & Branstetter, 2013; St. Aubin & Dierauf, 2001a)]. Because there are many unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, the Navy assumes in its effects analysis that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to disease and naturally occurring toxins, lack of prey availability, and interactions with predators all contribute to the stress a marine mammal experiences (Atkinson et al., 2015). Breeding cycles, periods of fasting, and social interactions with members of the same species are also stressors, although they are natural components of an animal's life history. Anthropogenic activities have the potential to provide additional stressors beyond those that occur naturally (Fair et al., 2014; Meissner et al., 2015; Rolland et al., 2012). Anthropogenic stressors potentially include such things as fishery interactions, pollution, tourism, and ocean noise.

The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor (Moberg & Mench, 2000). However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction). The generalized stress response is classically characterized by the release of cortisol, a hormone that has many functions including elevation of blood sugar, suppression of the immune system, and alteration of the biochemical pathways that affect fat, protein, and carbohydrate metabolism. However, it is now known that the endocrine response (glandular secretions of hormones into the blood) to a stressor can extend to other hormones. For instance, thyroid hormones can also vary under the influence of certain stressors, particularly food deprivation. These types of responses typically occur on the order of minutes to days. The "fight or flight" response, an acute stress response, is characterized by the very rapid release of hormones that stimulate glucose release, increase heart rate, and increase oxygen consumption.

What is known about the function of the various stress hormones is based largely upon observations of the stress response in terrestrial mammals. The endocrine response of marine mammals to stress may not be the same as that of terrestrial mammals because of the selective pressures marine mammals faced during their evolution in an ocean environment (Atkinson et al., 2015). For example, due to the necessity of breath-holding while diving and foraging at depth, the physiological role of epinephrine and norepinephrine (the catecholamines) in marine mammals might be different than in other mammals. Catecholamines increase during breath-hold diving in seals, co-occurring with a reduction in heart rate, peripheral vasoconstriction (constriction of blood vessels), and an increased reliance on anaerobic metabolism during extended dives (Hance et al., 1982; Hochachka et al., 1995; Hurford et al., 1996); the catecholamine increase is not associated with an increased heart rate, glycemic release, and increased oxygen consumption typical of terrestrial mammals. Other hormone functions might also be different, such as aldosterone, which has been speculated to not only contribute to electrolyte balance, but possibly also the maintenance of blood pressure during periods of vasoconstriction (Houser et al., 2011). In marine mammals, aldosterone is thought to play a particular role in stress mediation because of its pronounced increase in response to handling stress (St. Aubin & Dierauf, 2001a; St. Aubin & Geraci, 1989).

Relatively little information exists on the linkage between anthropogenic sound exposure and stress in marine mammals, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). Most studies to date have focused on acute responses to sound either by measuring catecholamines or by measuring heart rate as an assumed proxy for an acute stress response. Belugas demonstrated no catecholamine response to the playback of oil drilling sounds (Thomas et al., 1990b) but showed a small but statistically significant increase in catecholamines following exposure to impulsive 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 a statistically significant elevation in aldosterone (Romano et al., 2004), albeit the increase was within the normal daily variation observed in this species (St. Aubin et al., 1996). Increases in heart rate were observed in bottlenose dolphins to which known calls of other dolphins were played, although no increase in heart rate was observed when background tank noise was played back (Miksis et al., 2001). Unfortunately, in this study, it cannot be determined whether the increase in heart rate was due to stress or an anticipation of being reunited with the dolphin to which the vocalization belonged. Similarly, a young beluga's heart rate was observed to increase during exposure to noise, with increases dependent upon the frequency band of noise and duration of exposure, and with a sharp decrease to normal or below normal levels upon cessation of the exposure (Lyamin et al., 2011). Spectral analysis of heart rate variability corroborated direct measures of heart rate (Bakhchina et al., 2017). This response might have been in part due to the conditions during testing, the young age of the animal, and the novelty of the exposure; a year later the exposure was repeated at a slightly higher received level and there was no heart rate response, indicating the beluga whale had potentially acclimated to the noise exposure. Kvadsheim et al. (2010) measured the heart rate of captive hooded seals during exposure to sonar signals and found an increase in the heart rate of the seals during exposure periods versus control periods when the animals were at the surface. When the animals dove, the normal dive-related bradycardia (decrease in heart rate) was not impacted by the sonar exposure. Similarly, Thompson et al. (1998) observed a rapid but short-lived decrease in heart rates in harbor and grey seals exposed to seismic air guns (cited in Gordon et al., 2003). Williams et a. (2017) recently monitored the heart rates of narwhals released from capture and found that a profound dive bradycardia persisted, even though exercise effort increased dramatically as part of their escape response following release. Thus, although some limited evidence suggests that tachycardia might occur as part of the acute stress response of animals that are at the surface, the dive bradycardia persists during diving and might be enhanced in response to an acute stressor.

Whereas a limited amount of work has addressed the potential for acute sound exposures to produce a stress response, almost nothing is known about how chronic exposure to acoustic stressors affects stress hormones in marine mammals, particularly as it relates to survival or reproduction. In what is probably the only study of chronic noise exposure in marine mammals associating changes in a stress hormone with changes in anthropogenic noise, Rolland et al. (2012) compared the levels of cortisol metabolites in North Atlantic right whale feces collected before and after September 11, 2001. Following the events of September 11, shipping was significantly reduced in the region where fecal collections were made, and regional ocean background noise declined. Fecal cortisol metabolites significantly decreased during the period of reduced ship traffic and ocean noise (Rolland et al., 2012). Considerably more work has been conducted in an attempt to determine the potential effect of boating on smaller cetaceans, particularly killer whales (Bain, 2002; Erbe, 2002; Lusseau, 2006; Noren et al., 2009; Pirotta et al., 2015b; Rolland et al., 2012; Skarke et al., 2014; Williams et al., 2006; Williams et al., 2009; Williams et al., 2013; Williams et al., 2014b). Most of these efforts focused primarily on estimates of metabolic costs associated with altered behavior or inferred consequences of boat presence and noise, but did not directly measure stress hormones. However, Ayres et al. (2012) investigated southern resident killer whale fecal thyroid hormone and cortisol metabolites to assess two potential threats to the species recovery: lack of prey (salmon) and impacts from exposure to the physical presence of vessel traffic (but without measuring vessel traffic noise). Ayres et al. (2012) concluded from these stress hormone measures that the lack of prey overshadowed any population-level physiological impacts on southern resident killer whales due to vessel traffic. Collectively, these studies indicate the difficulty in teasing out factors that are dominant in exerting influence on the secretion of stress hormones, including the separate and additive effects of vessel presence and vessel noise. Nevertheless, although the reduced presence of the ships themselves cannot be ruled out as potentially contributing to the reduction in fecal cortisol metabolites in North Atlantic right whales, the work of Rolland et al. (2012) represents the most provocative link between ocean noise and cortisol in cetaceans to date.

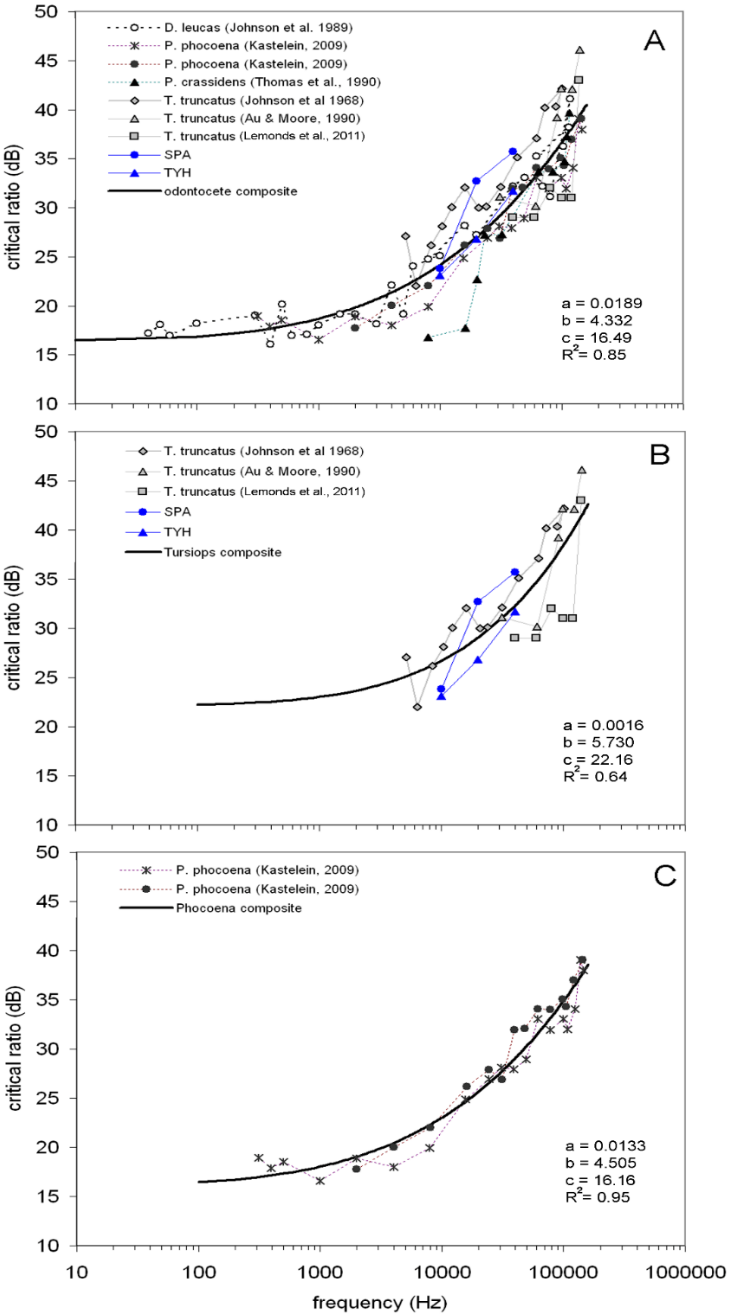
Navy-funded efforts are underway to try and improve our understanding and ability to predict how stressors ultimately affect marine mammal populations (e.g., King et al., 2015; New et al., 2013a; New et al., 2013c; Pirotta et al., 2015a), and to determine whether a marine mammal being naïve or experienced with the sound (e.g., prior experience with a stressor) may result in a reduced response due to habituation (St. Aubin & Dierauf, 2001b).

3.4.2.1.1.4 Masking

Masking occurs when one sound, distinguished as the “noise,” interferes with the detection, discrimination, or recognition of another sound. The quantitative definition of masking is the amount in decibels an auditory detection, discrimination, or recognition threshold is raised in the presence of a masker (Erbe et al., 2016). As discussed in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking can lead to vocal changes (e.g., Lombard effect, increasing amplitude, or changing frequency) and behavior changes (e.g., cessation of foraging, leaving an area) to both signalers and receivers, in an attempt to compensate for noise levels (Erbe et al., 2016).

Critical ratios are the lowest signal-to-noise ratio in which detection occurs (Finneran & Branstetter, 2013; Johnson et al., 1989; Southall et al., 2000). When expressed in dB, critical ratios can easily be calculated by subtracting the noise level (in dB re 1 μPa^2/Hz) from the signal level (in dB re 1 μPa) at threshold. Critical ratios have been measured for pinnipeds (Southall et al., 2000, 2003; Thomas et al., 1990a), odontocetes (see Figure 3.4-3) (Au & Moore, 1990; Branstetter et al., 2017b; Johnson et al., 1989; Kastelein & Wensveen, 2008; Lemonds et al., 2011), manatees (Gaspard et al., 2012), and sea otters (Ghoul & Reichmuth, 2014). Critical ratios are directly related to the bandwidth of auditory filters; as a result, critical ratios increase as a function of signal frequency (Au & Moore, 1990; Lemonds et al., 2011). Higher frequency noise is more effective at masking higher frequency signals. Composite critical ratio functions have been estimated for odontocetes, which allows predictions of masking if the spectral density of noise is known (Branstetter et al., 2017b). Although critical ratios are typically estimated in controlled laboratory conditions using Gaussian (white) noise, critical ratios can vary considerably (see Figure 3.4-4) depending on the noise type (Branstetter et al., 2013; Branstetter et al., 2017b; Trickey et al., 2010)

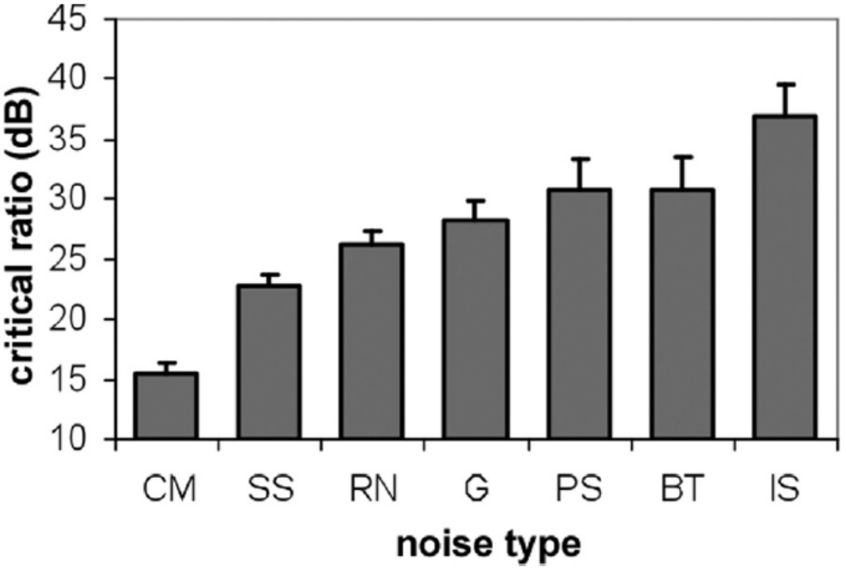
Clark et al. (2009) developed a model for estimating masking effects on communication signals for low-frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, the model estimates that a right whale's optimal communication space (around 20 km) is decreased by 84 percent when two commercial ships pass through it. Similarly, Aguilar de Soto et al. (2006) found that a 15 dB increase in background noise due to vessels led to a communication range of only 18 percent of its normal value for foraging beaked whales. This method relies on empirical data on source levels of calls (which is unknown for many species) and requires many assumptions such as pre-industrial ambient noise conditions and simplifications of animal hearing and behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Erbe (2016) developed a model with a noise source-centered view of masking to examine how a call may be masked from a receiver by a noise as a function of caller, receiver, and noise-source location; distance relative to each other; and received level of the call.



Source: Branstetter et al. (2017b)

Notes: (A) Odontocete critical ratios and composite model: $CR = a[\log10(f)]^b + c$, where *a*, *b*, and *c* are model coefficients and *f* is the signal frequency in Hz. Equation 1 was fit to aggregate data for all odontocetes. (B) *T. truncatus* critical ratios and composite model. (C) *P. phocoena* critical ratios and composite model. Parameter values for composite models are displayed in the lower right of each panel

Figure 3.4-3: Odontocete Critical Ratios



Source: Branstetter et al. (2013)
Notes: CM = comodulated, SS = snapping shrimp, RN = rain noise, G = Gaussian, PS = pile saw, BT = boat engine noise, and IS = ice squeaks

Figure 3.4-4: Critical Ratios for Different Noise Types

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. Vocalization changes include increasing the source level, modifying the frequency, increasing the call repetition rate of vocalizations, or ceasing to vocalize in the presence of increased noise (Hotchkin & Parks, 2013). In cetaceans, vocalization changes were reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying (Gordon et al., 2003; Holt et al., 2008; Holt et al., 2011; Lesage et al., 1999; McDonald et al., 2009; Rolland et al., 2012) as well as changes in the natural acoustic environment (Dunlop et al., 2014). Vocal changes can be temporary, or can be persistent, as seen in the increase in starting frequency for the North Atlantic right whale upcall over the last 50 years (Tennessen & Parks, 2016). Model simulation suggests that the frequency shift resulted in increased detection ranges between right whales; the frequency shift, coupled with an increase in call intensity by 20 dB, led to a call detectability range of less than 3 km to over 9 km (Tennessen & Parks, 2016). In some cases, these vocal changes may have fitness consequences, such as an increase in metabolic rates and oxygen consumption, as was found for bottlenose dolphins when increasing their call amplitude (Holt et al., 2015). A switch from vocal communication to physical, surface-generated sounds such as pectoral fin slapping or breaching was observed for humpback whales in the presence of increasing natural background noise levels, indicating that adaptations to masking may also move beyond vocal modifications (Dunlop et al., 2010). These changes all represent possible tactics by the sound-producing animal to reduce the impact of masking. The receiving animal can also reduce masking by using active listening strategies such as orienting to the sound source, moving to a quieter location, or reducing self-noise from hydrodynamic flow by remaining still. The temporal structure of noise (e.g., amplitude modulation) may also provide a considerable release from masking through comodulation masking release (a reduction of masking that occurs when broadband noise, with a frequency spectrum wider than an animal's auditory filter bandwidth at the frequency of interest, is amplitude modulated)

(Branstetter & Finneran, 2008; Branstetter et al., 2013). Signal type (e.g., whistles, burst-pulse, sonar clicks) and spectral characteristics (e.g., frequency modulated with harmonics) may further influence masked detection thresholds (Branstetter et al., 2016; Cunningham et al., 2014).

Informational Masking

Much emphasis has been placed on signal detection in noise, and as a result, most masking studies and communication space models have focused on masked detection thresholds. However, from a fitness perspective, signal detection is almost meaningless without the ability to determine the sound source location and recognize “what” is producing the sound. Marine mammals use sound to recognize conspecifics, prey, predators, or other biologically significant sources (Branstetter et al., 2016). Masked recognition thresholds (often called informational masking) for whistle-like sounds have been measured for bottlenose dolphins (Branstetter et al., 2016), and are approximately 4 dB above detection thresholds (energetic masking) for the same signals. It should be noted that the term “threshold” typically refers to the listener’s ability to detect or recognize a signal 50 percent of the time. For example, human speech communication where only 50 percent of the words are recognized would result in poor communication (Branstetter et al., 2016). Likewise, recognition of a conspecific call or the acoustic signature of a predator at only the 50 percent level could have severe negative impacts. If “quality communication” is arbitrarily set at 90 percent recognition (which may be more appropriately related to animal fitness), the output of communication space models (which are based on 50 percent detection) would likely result in a significant decrease in communication range (Branstetter et al., 2016).

Marine mammals use sound to recognize predators (Allen et al., 2014; Cummings & Thompson, 1971; Curé et al., 2015; Fish & Vania, 1971). Auditory recognition may be reduced in the presence of a masking noise, particularly if it occurs in the same frequency band. Therefore, the occurrence of masking may prevent marine mammals from responding to the acoustic cues produced by their predators. Whether this is a possibility depends on the duration of the masking and the likelihood of encountering a predator during the time that detection and recognition of predator cues are impeded. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by mammal-eating killer whales. The seals acoustically discriminate between the calls of mammal-eating and fish-eating killer whales (Deecke et al., 2002), a capability that should increase survivorship while reducing the energy required to attend to all killer whale calls. Similarly, sperm whales (Curé et al., 2016; Isojunno et al., 2016), long-finned pilot whales (Visser et al., 2016), and humpback whales (Curé et al., 2015) changed their behavior in response to killer whale vocalization playbacks; these findings indicate that some recognition of predator cues could be missed if the killer whale vocalizations were masked.

Masking by Sonar and Other Transducers

Masking by low-frequency or mid-frequency active sonar with relatively low-duty cycles is unlikely for most cetaceans and pinnipeds as sonar signals occur over a relatively short duration, and narrow bandwidth that does not overlap with vocalizations for most marine mammal species. While dolphin whistles and mid-frequency active sonar are similar in frequency, masking is unlikely due to the low-duty cycle of most sonars. Low-frequency active sonar could also overlap with mysticete vocalizations (e.g., minke and humpback whales). For example, in the presence of low-frequency active sonar, humpback whales were observed to increase the length of their songs (Fristrup et al., 2003; Miller et al., 2000), possibly due to the overlap in frequencies between the whale song and the low-frequency active sonar.

Newer high-duty cycle or continuous active sonars have more potential to mask vocalizations, particularly for delphinids and other mid-frequency cetaceans. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, high-frequency acoustic sources such as pingers that operate at higher repetition rates (e.g., 2–10 kHz with harmonics up to 19 kHz, 76 to 77 pings per minute (Culik et al., 2001), also operate at lower source levels. While the lower source levels limit the range of impact compared to traditional systems, animals close to the sonar source are likely to experience masking on a much longer time scale than those exposed to traditional sonars. The frequency range at which high-duty cycle systems operate overlaps the vocalization frequency of many mid-frequency cetaceans. Continuous noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, and acoustically mediated cooperative behaviors such as foraging or reproductive activities. Similarly, because the systems are mid-frequency, there is the potential for the sonar signals to mask important environmental cues like predator vocalizations (e.g., killer whales), possibly affecting survivorship for targeted animals. While there are currently no available studies of the impacts of high-duty cycle sonars on marine mammals, masking due to these systems is likely analogous to masking produced by other continuous sources (e.g., vessel noise and low-frequency cetaceans), and would likely have similar short-term consequences, though longer in duration due to the duration of the masking noise. These may include changes to vocalization amplitude and frequency (Brumm & Slabbekoorn, 2005; Hotchkin & Parks, 2013) and behavioral impacts such as avoidance of the area and interruptions to foraging or other essential behaviors (Gordon et al., 2003). Long-term consequences could include changes to vocal behavior and vocalization structure (Foote et al., 2004; Parks et al., 2007), abandonment of habitat if masking occurs frequently enough to significantly impair communication (Brumm & Slabbekoorn, 2005), a potential decrease in survivorship if predator vocalizations are masked (Brumm & Slabbekoorn, 2005), and a potential decrease in recruitment if masking interferes with reproductive activities or mother-calf communication (Gordon et al., 2003).

Masking by Vessel Noise

Masking is more likely to occur in the presence of broadband, relatively continuous noise sources such as vessels. For example, right whales were 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) as well as increasing the amplitude (intensity) of their calls (Parks, 2009; Parks et al., 2011). Right whales also had their communication space reduced by up to 84 percent in the presence of vessels (Clark et al., 2009). However, Cholewiak et al. (2018) found that right whale gunshot calls had the lowest loss of communication space in Stellwagen National Sanctuary (5 percent), while fin and humpback whales lost up to 99 percent of their communication space with increased ambient noise and shipping noise combined. Although humpback whales off Australia did not change the frequency or duration of their vocalizations in the presence of ship noise, their source levels were lower than expected based on source level changes to wind noise, potentially indicating some signal masking (Dunlop, 2016).

Multiple delphinid species have also been shown to increase the minimum or maximum frequencies of their whistles in the presence of anthropogenic noise (Papale et al., 2015). More specifically, Williams et al. (2013) found that in median noise conditions in Haro Strait, killer whales lose 62 percent of their acoustic communication space due to vessel traffic noise, and in peak traffic hours lose up to 97 percent of that space. Holt et al. (2008; 2011) showed that southern resident killer whales in the waters surrounding the San Juan Islands increased their call source level as vessel noise increased. Hermannsen et al. (2014) estimated that broadband vessel noise could extend up to 160 kHz at ranges from 60 to 1,200 m, and that the higher frequency portion of that noise might mask harbor porpoise clicks. However, this may not be an issue as harbor porpoises may avoid vessels and may not be close enough to have their clicks masked (Dyndo et al., 2015; Polacheck & Thorpe, 1990; Sairanen, 2014). Furthermore, Hermannsen et al. (2014) estimated that a 6 dB elevation in noise would decrease the hearing range of a harbor porpoise by 50 percent, and a 20 dB increase in noise would decrease the hearing range by 90 percent. Dugong vocalizations were recorded in the presence of passing boats, and although the call rate, intensity, and frequency of the calls did not change, the duration of the vocalizations was increased, as was the presence of harmonics. This may indicate more energy was being used to vocalize in order to maintain the same received level (Ando-Mizobata et al., 2014). Gervaise et al. (2012) estimated that beluga whales in the St. Lawrence Marine Park had their communication space reduced to 30 percent during average vessel traffic. During peak traffic, communication space was further reduced to 15 percent. Lesage et al. (1999) found belugas in the St. Lawrence River estuary reduced overall call rates but increased the production of certain call types when ferry and small outboard motor boats were approaching. Furthermore, these belugas increased the vocalization frequency band when vessels were in close proximity. Liu et al. (2017) found that broadband shipping noise could cause masking of humpback dolphin whistles within 1.5–3 km, and masking of echolocation clicks within 0.5–1.5 km.

3.4.2.1.1.5 Behavioral Reactions

As discussed in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), any stimulus in the environment can cause a behavioral response in marine mammals. These stimuli include noise from anthropogenic sources such as vessels, sonar, or aircraft, but could also include the physical presence of a vessel or aircraft. However, these stimuli could also influence how or if a marine mammal responds to a sound such as the presence of predators, prey, or conspecifics. Furthermore, the response of a marine mammal to an anthropogenic sound may depend on the frequency, duration, temporal pattern and amplitude of the sound as well as the animal's prior experience with the sound and their behavioral state (i.e., what the animal is doing and their energetic needs at the time of the exposure) (Ellison et al., 2011). The distance from the sound source and whether it is approaching or moving away can also 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 et al. (1995b). Other reviews (Nowacek et al., 2007a; Southall et al., 2007) addressed studies conducted since 1995 and focused on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated, and also examined the role of context. 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; Southall et al., 2016). Ellison et al. (2011) outlined an approach to assessing the effects of sound on marine mammals that incorporates these contextual-based factors. They recommend considering not just the received level of sound, but also in what activity the animal is engaged, the nature and novelty of the sound (i.e., 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 (see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a)). Forney et al. (2017) also point out that an apparent lack of response (e.g., no displacement or avoidance of a sound source) may not necessarily mean there is no cost to the individual or population, as some resources or habitats may be of such high value that animals may choose to stay, even when experiencing stress or hearing loss. Forney et al. (2017) recommend considering both the costs of remaining in an area of noise exposure such as TTS, PTS, or masking, which could lead to an increased risk of predation or other threats or a decreased capability to forage, and the costs of displacement, including potential increased risk of vessel strike or bycatch, increased risks of predation or competition for resources, or decreased habitat suitable for foraging, resting, or socializing.

Behavioral reactions could result from a variety of sound sources such as sonar and other active acoustic sources (e.g., pingers), vessel noise, and aircraft noise. There is data on the reactions of some species in different behavioral states, providing evidence on the importance of context in gauging a behavioral response. However, for most species, little or no data exist on behavioral responses to any sound source, and so all species have been grouped into broad taxonomic groups from which general response information can be inferred (see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a)).

Behavioral Reactions to Sonar and Other Transducers

Sonar and other transducers can range in frequency from less than 1 kHz (e.g., low-frequency active sonar) to over 200 kHz (e.g., fish finders), with duty cycles that range from one ping per minute to an almost continuous sound. Although very high-frequency sonars are out of the hearing range of most marine mammals, some of these sources may contain artifacts at lower frequencies that could be detected (Deng et al., 2014; Hastie et al., 2014). High-duty cycle sonar systems operate at lower source levels, but with a more continuous sound output. These sources can be stationary, or on a moving platform, and there can be more than one source present at a time. Guan et al. (2017) also found that sound levels in the mid-frequency sonar bandwidth remained elevated at least 5 dB above background levels for the first 7–15 seconds (within 2 km) after the emission of a sonar ping; depending on the length of the sonar ping and the inter-ping interval, this reverberation could increase cumulative SEL estimates during periods of active sonar. This variability in parameters associated with sonar and other transducers makes the estimation of behavioral responses to these sources difficult, with observed responses ranging from no apparent change in behavior to more severe responses that could lead to some costs to the animal. As discussed in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) and Section 3.4.2.1.1.5 (Behavioral Reactions), responses may also occur in the presence of different contextual factors regardless of received level, including the proximity and number of vessels, the behavioral state and prior experience of an individual, and even characteristics of the signal itself or the propagation of the signal through the environment.

In order to explore this complex question, behavioral response studies have been conducted through the collaboration of various research and government organizations in Bahamian, United States (off Southern California), Mediterranean, Australian, and Norwegian waters. These studies have attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to understand better their potential impacts. While controlling for as many variables as possible (e.g., the distance and movement of the source), these studies also introduce additional variables that do not normally occur in a real Navy training or testing activity, including the tagging of whales, following the tagged animals with multiple vessels, and continually approaching the animal to create a dose escalation. In addition, distances of the sound source from the whales during behavioral response studies were always within 1–8 km. Some of these studies have suggested that ramping up a source from a lower source level would act as a mitigation measure to protect against higher order (e.g., TTS or PTS) impacts of some active sonar sources; however, this practice may only be effective for more responsive animals, and for short durations (e.g., five minutes) of ramp-up (von Benda-Beckmann et al., 2014; von Benda-Beckmann et al., 2016). Therefore, while these studies have provided the most information to date on behavioral responses of marine mammals to sonar, there are still many contextual factors to be teased apart, and determining what might produce a significant behavioral response is not a trivial task. Additional information about active sonar ramp-up procedures, including why the Navy will not implement them as mitigation under the Proposed Action, is provided in Section 5.6.1 (Active Sonar).

Passive acoustic monitoring and visual observational behavioral response studies have also been conducted on Navy ranges, taking advantage of the existing seafloor hydrophones and real training and testing activity and associated sources to assess behavioral responses (Deakos & Richlen, 2015; Henderson et al., 2016; Manzano-Roth et al., 2016; Martin et al., 2015; McCarthy et al., 2011; Mobley & Deakos, 2015; Moretti et al., 2014; Tyack et al., 2011). In addition, extensive aerial, visual, and passive acoustic monitoring have been conducted before, during, and after training events to watch for behavioral responses during training and look for injured or stranded animals after training (Falcone et al., 2017; Farak et al., 2011; HDR, 2011b; Henderson et al., 2016; Manzano-Roth et al., 2016; Norris et al., 2012b; Smultea & Mobley, 2009; Smultea et al., 2009; Trickey et al., 2015; U.S. Department of the Navy, 2011a, 2013b, 2014a, 2015b). During all of these monitoring efforts, very few behavioral responses were observed, and no injured or dead animal was observed that was directly related to a training event (some dead animals were observed but typically before the event or appeared to have been deceased prior to the event; e.g., Smultea et al., 2011). While passive acoustic studies are limited to observations of vocally active marine mammals, and visual studies are limited to what can be observed at the surface, these study types have the benefit of occurring in the absence of some of the added contextual variables in the controlled exposure studies. Furthermore, when visual and passive acoustic data collected during a training event are combined with ship movements and sonar use, and with tagged animal data when possible, they provide a unique and realistic scenario for analysis, as in Falcone et al. (2017), Manzano-Roth et al. (2016) or Baird et al. (2017). In addition to these types of observational behavioral response studies, Harris & Thomas (2015) highlighted additional research approaches that may provide further information on behavioral responses to sonars and other transducers beyond behavior response type studies or passive acoustic monitoring, including conducting controlled exposures on captive animals with scaled (smaller sized and deployed at closer proximity) sources, on wild animals with both scaled and real but directed sources, and predator playback studies, all of which will be discussed below.

The above behavioral response studies and observations have been conducted on a number of mysticete and odontocete species, which can be extrapolated to other similar species in these taxonomic groups. No field studies of pinniped behavioral responses to sonar have been conducted; however, there are several captive studies on some pinniped and odontocete species that can provide insight into how these animals may respond in the wild. The captive studies typically represent a more controlled approach, which allow researchers to better estimate the direct impact of the received level of sound leading to behavioral responses, and to potentially link behavioral to physiological responses. However, there are still contextual factors that must be acknowledged, including previous training to complete tasks and the presence of food rewards upon completion. There are no corresponding captive studies on mysticete whales, therefore some of the responses to higher-level exposures must be extrapolated from odontocetes.

Mysticetes

The responses of mysticetes to sonar and other duty-cycled tonal sounds are highly dependent upon the characteristics of the signal, the behavioral state of the animal, the particular sensitivity and previous experience of an individual, and other contextual factors including distance of the source, movement of the source, and the physical presence of vessels in addition to the sonar (Goldbogen et al., 2013b; Harris et al., 2015; Martin et al., 2015; Sivle et al., 2015). Behavioral response studies have been conducted over a variety of contextual and behavioral states, helping to identify which contextual factors may lead to a response beyond just the received level of the sound. Observed reactions during behavioral response studies have not been consistent across individuals based on received sound levels alone, and likely were the result of complex interactions between these contextual factors.

Surface feeding blue whales did not show a change in behavior in response to mid-frequency simulated and real sonar sources with received levels between 90 and 179 dB re 1 µPa, but deep feeding and non-feeding whales showed temporary reactions including cessation of feeding, reduced initiation of deep foraging dives, generalized avoidance responses, and changes to dive behavior (DeRuiter et al., 2017; Goldbogen et al., 2013b; Sivle et al., 2015). Similarly, while the rates of foraging lunges decreased in humpback whales due to sonar exposure, there was variability in the response across individuals, with one animal ceasing to forage completely and another animal starting to forage during the exposure (Sivle et al., 2016). In addition, lunges decreased (although not significantly) during a no-sonar control vessel approach prior to the sonar exposure, and lunges decreased less during a second sonar approach than during the initial approach, possibly indicating some response to the vessel and some habituation to the sonar and vessel after repeated approaches. In the same experiment, most of the non-foraging humpback whales did not respond to any of the approaches (Sivle et al., 2016). These humpback whales also showed variable avoidance responses, with some animals avoiding the sonar vessel during the first exposure but not the second, while others avoided the sonar during the second exposure, and only one avoided both. In addition, almost half of the animals that avoided were foraging before the exposure but the others were not; the animals that avoided while not feeding responded at a slightly lower received level and greater distance than those that were feeding (Wensveen et al., 2017). These findings indicate that the behavioral state of the animal plays a role in the type and severity of a behavioral response. In fact, when the prey field was mapped and used as a covariate in similar models looking for a response in the same blue whales, the response in deep-feeding behavior by blue whales was even more apparent, reinforcing the need for contextual variables to be included when assessing behavioral responses (Friedlaender et al., 2016). However, even when responses did occur the animals quickly returned to their previous behavior after the sound exposure ended (Goldbogen et al., 2013b; Sivle et al., 2015). In another study, humpback whales exposed to a 3 kHz pinger meant to act as a net alarm to prevent entanglement did not respond or change course, even when within 500 m (Harcourt et al., 2014). However, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives; in this case, the alarm was comprised of a mixture of signals with frequencies from 500 to 4500 Hz, was long in duration (lasting several minutes), and was purposely designed to elicit a reaction from the animals as a prospective means to protect them from ship strikes (Nowacek et al., 2004). Although the animals' received SPL was similar in the latter two studies (133–150 dB re 1 $\mu Pa^2 s$), the frequency, duration, and temporal pattern of signal presentation were different.

Humpback whales in another behavioral response experiment in Australia also responded to a 2 kHz tone stimulus by changing their course during migration to move more offshore and surfaced more frequently, but otherwise did not respond (Dunlop et al., 2013). Humpback whales in the Norwegian behavioral response study may have habituated slightly between the first and second sonar exposure (Sivle et al., 2015), and actually responded more severely to killer whale vocalization playbacks than they did to the sonar playbacks. Several humpback whales have been observed during aerial or visual surveys during Navy training events involving sonar; no avoidance or other behavioral responses were ever noted, even when the whales were observed within 5 km of a vessel with active (or possibly active) sonar and maximum received levels were estimated to be between 135 and 161 dB re 1 µPa (Mobley & Milette, 2010; Mobley, 2011; Mobley & Pacini, 2012; Mobley et al., 2012; Smultea et al., 2009). In fact, one group of humpback whales approached a vessel with active sonar so closely that the sonar was shut down and the vessel slowed; the animals continued approaching and swam under the bow of the vessel (U.S. Department of the Navy, 2011b). Another group of humpback whales continued heading towards a vessel with active sonar as the vessel was moving away for almost 30 minutes, with an estimated median received level of 143 dB re 1 µPa. This group was observed producing surface active behaviors such as pec slaps, tail slaps, and breaches; however, these are very common behaviors in competitive pods during the breeding season and were not considered to have occurred in response to the sonar (Mobley et al., 2012).

The strongest baleen whale response in any behavioral response study was observed in a minke whale in the 3S2 study, which responded at 146 dB re 1 µPa by strongly avoiding the sound source (Kvadsheim et al., 2017; Sivle et al., 2015). Although the minke whale increased its swim speed, directional movement, and respiration rate, none of these were greater than rates observed in baseline behavior, and its dive behavior remained similar to baseline dives. A minke whale tagged in the Southern California behavioral response study also responded by increasing its directional movement, but maintained its speed and dive patterns, and so did not demonstrate as strong of a response (Kvadsheim et al., 2017). In addition, the 3S2 minke whale demonstrated some of the same avoidance behavior during the controlled ship approach with no sonar, indicating at least some of the response was to the vessel (Kvadsheim et al., 2017). Martin et al. (2015) found that the density of calling minke whales was reduced during periods of Navy training involving sonar relative to the periods before training, and increased again in the days after training was completed. The responses of individual whales could not be assessed, so in this case it is unknown whether the decrease in calling animals indicated that the animals left the range, or simply ceased calling. Similarly, minke whale detections made using Marine Acoustic Recording Instruments off Jacksonville, FL, were reduced or ceased altogether during periods of sonar use (Simeone et al., 2015; U.S. Department of the Navy, 2013b), especially with an increased ping rate (Charif et al., 2015). Two minke whales also stranded in shallow water after the U.S. Navy training event in the Bahamas in 2000, although these animals were successfully returned to deep water with no physical examinations; therefore, no final conclusions were drawn on whether the sonar led to their stranding (Filadelfo et al., 2009a; Filadelfo et al., 2009b; U.S. Department of Commerce & U.S. Department of the Navy, 2001).

Baleen whales have also been exposed to lower frequency sonars, with the hypothesis that these whales may react more strongly to lower frequency sounds that overlap with their vocalization range. One series of studies was undertaken in 1997–1998 pursuant to the Navy's Low-Frequency Sound Scientific Research Program. The frequency bands of the low-frequency sonars used were between 100 and 500 Hz, with received levels between 115 and 150 dB re 1 µPa, and the source was always stationary. Fin and blue whales were targeted on foraging grounds, singing humpback whales were exposed on breeding grounds, and gray whales were exposed during migratory behavior. These studies found only short-term responses to low-frequency sound by some fin and humpback whales, including changes in vocal activity and avoidance of the source vessel, while other fin, humpback, and blue whales did not respond at all. When the source was in the path of migrating gray whales they changed course up to 2 km to avoid the sound, but when the source was outside their path, little response was observed, although received levels were similar (Clark & Fristrup, 2001; Croll et al., 2001; Fristrup et al., 2003; Miller et al., 2000; Nowacek et al., 2007a). Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source were also not found to affect dive times of humpback whales in Hawaiian waters (Frankel & Clark, 2000).

Opportunistic passive acoustic based studies have also detected behavioral responses to sonar, although definitive conclusions are harder to draw. 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, beginning at received levels of 110–120 dB re 1 µPa (Melcón et al., 2012); however, without visual observations it is unknown whether there was another factor that contributed to the reduction in foraging calls, such as the presence of conspecifics. In another example, Risch et al. (2012, 2014) determined that humpback whale song produced in the Stellwagen Bank National Marine Sanctuary was reduced, and since the timing was concurrent with an Ocean Acoustic Waveguide Remote Sensing experiment occurring 200 km away, they concluded that the reduced song was a result of the Ocean Acoustic Waveguide Remote Sensing. However, Gong et al. (2014) analyzed the same data set while also looking at the presence of herring in the region, and found that the singing humpbacks were actually located on nearby Georges Bank and not on Stellwagen, and that the song rate in their data did not change in response to Ocean Acoustic Waveguide Remote Sensing, but could be explained by natural causes.

Although some strong responses have been observed in mysticetes to sonar and other transducers (e.g., the single minke whale), for the most part mysticete responses appear to be fairly moderate across all received levels. While some responses such as cessation of foraging or changes in dive behavior could carry short-term impacts, in all cases behavior returned to normal after the signal stopped. Mysticete responses also seem to be highly mediated by behavioral state, with no responses occurring in some behavioral states, and contextual factors and signal characteristics having more impact than received level alone. Many of the contextual factors resulting from the behavioral response studies (e.g., close approaches by multiple vessels or tagging) would never be introduced in real Navy training and testing scenarios. While data are lacking on behavioral responses of mysticetes to continuously active sonars, these species are known to be able to habituate to novel and continuous sounds (Nowacek et al., 2004), suggesting that they are likely to have similar responses to high-duty cycle sonars. Therefore, mysticete behavioral responses to Navy sonar would likely be a result of the animal's behavioral state and prior experience rather than external variables such as ship proximity; thus, if significant behavioral responses occur they would likely be short term. In fact, no significant behavioral responses such as panic, stranding, or other severe reactions have been observed during monitoring of actual training exercises (Smultea et al., 2009; U.S. Department of the Navy, 2011a, 2014b; Watwood et al., 2012).

Odontocetes

Behavioral response studies have been conducted on odontocete species since 2007, with a focus on beaked whale responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge et al., 2009; Defence Science and Technology Laboratory, 2007; Falcone et al., 2017; Henderson et al., 2015b; Henderson et al., 2016; Manzano-Roth et al., 2016; McCarthy et al., 2011; Moretti et al., 2009; Southall et al., 2011; Southall et al., 2012; Southall et al., 2013; Southall et al., 2014; Southall et al., 2015; Tyack et al., 2011). Through analyses of these behavioral response studies, a preliminary overarching effect of greater sensitivity to most anthropogenic exposures was seen in beaked whales compared to the other odontocetes studied (Southall et al., 2009).

Observed reactions by Blainville's, Cuvier's, and Baird's beaked whales to mid-frequency sonar sounds have included cessation of clicking, termination of foraging dives, changes in direction to avoid the sound source, slower ascent rates to the surface, longer deep and shallow dive durations, and other unusual dive behavior (Boyd et al., 2008; Defence Science and Technology Laboratory, 2007; DeRuiter et al., 2013b; Miller et al., 2015; Southall et al., 2011; Stimpert et al., 2014; Tyack et al., 2011). A similar response was observed in a northern bottlenose whale, which conducted the longest and deepest dive on record for that species after the sonar exposure and continued swimming away from the source for over seven hours (Miller et al., 2015). Responses occurred at received levels between 95 and 150 dB re 1 µPa, although all of these exposures occurred within 1–8 km of the focal animal, within a few hours of tagging the animal, and with one or more boats within a few kilometers to observe responses and record acoustic data. One Cuvier's beaked whale was also incidentally exposed to real Navy sonar located over 100 km away, and the authors did not detect similar responses at comparable received levels. Received levels from the mid-frequency active sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa, respectively, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor in the responses to the simulated sonars (DeRuiter et al., 2013b). Falcone et al. (2017) modeled deep and shallow dive durations, surface interval durations, and inter-deep dive intervals of Cuvier's beaked whales against predictor values that included helicopter-dipping, mid-power mid-frequency active sonar and hull-mounted, high-power mid-frequency active sonar along with other, non-mid-frequency active sonar predictors. They found both shallow and deep dive durations to increase as the proximity to both mid- and high-powered sources decreased, and found surface intervals and inter-deep dive intervals to also increase in the presence of both types of sonars, although surface intervals shortened during periods of no mid-frequency active sonar. The responses to the mid-power mid-frequency active sonar at closer ranges were comparable to the responses to the higher SL ship sonar, again highlighting the importance of proximity. This study also supports context as a response factor, as helicopter-dipping sonars are shorter duration and randomly located, so more difficult for beaked whales to predict or track and therefore potentially more likely to cause a response, especially when they occur at closer distances (6–25 km in this study). Watwood et al. (2017) found that helicopter-dipping events occurred more frequently but with shorter durations than periods of hull-mounted sonar, and also found that the longer the duration of a sonar event, the greater reduction in detected Cuvier's beaked whale group dives. Therefore, when looking at the number of detected group dives, there was a greater reduction during periods of hull-mounted sonar than during helicopter-dipping sonar. Long-term tagging work has demonstrated that the longer duration dives considered a behavioral response by DeRuiter et al. (2013b) fell within the normal range of dive durations found for eight tagged Cuvier's beaked whales on the Southern California Offshore Range (Schorr et al., 2014). However, the longer inter-deep dive intervals found by DeRuiter et al. (2013b), which were among the longest found by Schorr et al. (2014) and Falcone et al. (2017), could indicate a response to sonar. In addition, Williams et al. (2017) note that in normal deep dives or during fast swim speeds, beaked whales and other marine mammals use strategies to reduce their stroke rates, including leaping or wave surfing when swimming, and interspersing glides between bouts of stroking when diving. They determined that in the post-exposure dives by the tagged Cuvier's beaked whales described in DeRuiter et al. (2013b), the whales ceased gliding and swam with almost continuous strokes. This change in swim behavior was calculated to increase metabolic costs about 30.5 percent and increase the amount of energy expending on fast swim speeds from 27 to 59 percent of their overall energy budget. This repartitioning of energy was detected in the model up to 1.7 hours after the single sonar exposure. Therefore, while the overall post-exposure dive durations were similar, the metabolic energy calculated by Williams et al. (2017) was higher.

On Navy ranges, Blainville's beaked whales located on the range appear to move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge et al., 2009; Henderson et al., 2015b; Manzano-Roth et al., 2016; McCarthy et al., 2011; Moretti et al., 2009; Tyack et al., 2011). However, Blainville's beaked whales remain on the range to forage throughout the rest of the year (Henderson et al., 2016), possibly indicating that this a preferred foraging habitat regardless of the effects of the noise, or it could be that there are no long-term consequences of the sonar activity. Similarly, photo-identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years, with re-sightings up to seven years apart, indicating a possibly resident population on the range (Falcone et al., 2009; Falcone & Schorr, 2014).

Beaked whales may respond similarly to shipboard echosounders, commonly used for navigation, fisheries, and scientific purposes, with frequencies ranging from 12 to 400 kHz and source levels up to 230 dB re 1 µPa but typically a very narrow beam (Cholewiak et al., 2017). During a scientific cetacean survey, an array of echosounders was used in a one-day-on, one-day-off paradigm. Beaked whale acoustic detections occurred predominantly (96 percent) when the echosounder was off, with only four detections occurring when it was on. Beaked whales were sighted fairly equally when the echosounder was on or off, but sightings were further from the ship when the echosounder was on (Cholewiak et al., 2017). These findings indicate that the beaked whales may be avoiding the area and may cease foraging near the echosounder.

Tyack et al. (2011) hypothesized that beaked whale responses to sonar may represent an anti-predator response. To test this idea, vocalizations of a potential predator—a killer whale—were also played back to a Blainville's beaked whale. This exposure resulted in a similar but more pronounced reaction than that elicited by sonar playback, which included longer inter-dive intervals and a sustained straight-line departure of more than 20 km from the area (Allen et al., 2014; Tyack et al., 2011). This anti-predator hypothesis was also tested by playing back killer whale vocalizations to pilot whales, sperm whales, and even other killer whales, to determine responses by both potential prey and conspecifics (Miller et al., 2011; Miller, 2012). Results varied, from no response by killer whales to an increase in group size and attraction to the source in pilot whales (Curé et al., 2012).

While there has been a focus on beaked whale responses to sonar, other species have been studied during behavioral response studies as well, including pilot whales, killer whales, and sperm whales. Responses by these species have also included horizontal avoidance, changes in behavioral state, and changes in dive behavior (Antunes et al., 2014; Miller et al., 2011; Miller, 2012; Miller et al., 2014). Additionally, separation of a killer whale calf from its group during exposure to mid-frequency sonar playback was observed (Miller et al., 2011). Received level thresholds at the onset of avoidance behavior were generally higher for pilot whales (mean 150 dB re 1 µPa) and sperm whales (mean 140 dB re 1 µPa) than killer whales (mean 129 dB re 1 µPa) (Antunes et al., 2014; Miller, 2012; Miller et al., 2014). A close examination of the tag data from the Norwegian groups showed that responses seemed to be behaviorally or signal frequency mediated. For example, killer whales only changed their dive behavior when doing deep dives at the onset of 1–2 kHz sonar (sweeping across frequencies), but did not change their dive behavior if they were deep diving during 6–7 kHz sonar (sweeping across frequencies). Nor did they change their dive behavior if they were conducting shallow dives at the onset of either type of sonar. Similarly, pilot whales and sperm whales performed normal deep dives during 6–7 kHz sonar, while during 1–2 kHz sonar the pilot whales conducted fewer deep dives and the sperm whales performed shorter and shallower dives (Sivle et al., 2012). In addition, pilot whales were also more likely to respond to lower received levels when non-feeding than feeding during 6–7 kHz sonar exposures, but were more likely to respond at higher received levels when non-feeding during 1–2 kHz sonar exposures. Furthermore, pilot whales exposed to a 38 kHz downward-facing echosounder did not change their dive and foraging behavior during exposure periods, although the animals' heading variance increased and fewer deep dives were conducted (Quick et al., 2017). In contrast, killer whales were more likely to respond to either sonar type when non-feeding than when feeding (Harris et al., 2015). These results again demonstrate that the behavioral state of the animal mediates the likelihood of a behavioral response, as do the characteristics (e.g., frequency) of the sound source itself.

Other responses during behavioral response studies included the synchronization of pilot whale surfacings with sonar pulses during one exposure, possibly as a means of mitigating the sound (Wensveen et al., 2015), and mimicry of the sonar with whistles by pilot whales (Alves et al., 2014), false killer whales (DeRuiter et al., 2013b) and Risso's dolphins (Smultea et al., 2012). In contrast, in another study melon-headed whales had "minor transient silencing" (a brief, non-lasting period of silence) after each 6–7 kHz signal, and (in a different oceanographic region) pilot whales had no apparent response (DeRuiter et al., 2013a). The probability of detecting delphinid vocalizations (whistles, clicks, and buzzes) increased during periods of sonar relative to the period prior to sonar in a passive acoustic study using Marine Autonomous Recording Units in the Jacksonville Range Complex, while there was no impact of sonar to the probability of detecting sperm whale clicks (Charif et al., 2015; U.S. Department of the Navy, 2013c).

In addition, killer whale sighting data from the same region in Norway as the behavioral response study was used to compare the presence or absence of whales from other years against the period with sonar. The authors found a strong relationship between the presence of whales and the abundance of herring, and only a weak relationship between the whales and sonar activity (Kuningas et al., 2013). Baird et al. (2013b; 2014; 2017) also tagged four shallow-diving odontocete species (rough-toothed dolphins, pilot whales, bottlenose dolphins, and false killer whales) in Hawaii off the Pacific Missile Range Facility before Navy training events. None of the tagged animals demonstrated a large-scale avoidance response to the sonar as they moved on or near the range, in some cases even traveling towards areas of higher noise levels, while estimated received SPLs varied from 130 to 168 dB re 1 µPa and distances from sonar sources ranged between 3.2 and 94.4 km. However, one pilot whale did have reduced dive rates (from 2.6 dives per hour before to 1.6 dives per hour during) and deeper dives (from a mean of 124 m to 268 m) during a period of sonar exposure. Baird et al. (2016) also tagged four short-finned pilot whales from both the resident island-associated population and from the pelagic population. The core range for the pelagic population was over 20 times larger than for the pelagic population, leading Baird et al. (2016) to hypothesize that that likelihood of exposure to mid-frequency active sonar, and therefore the potential for response, would be very different between the two populations. These diverse examples demonstrate that responses can be varied, are often context- and behavior-driven, and can be species and even exposure specific.

Other opportunistic observations of behavioral responses to sonar have occurred as well, although in those cases it is difficult to attribute observed responses directly to the sonar exposure, or to know exactly what form the response took. For example, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test, with transmissions centered at 57 Hz and up to

220 dB re 1 µPa (Bowles et al., 1994), although it could not be determined whether the animals ceased sound production or left the area. In May 2003, killer whales in Haro Strait, Washington, exhibited what were believed by some observers to be aberrant behaviors, during which time the USS Shoup was in the vicinity and engaged in mid-frequency active sonar operations. Sound fields modeled for the USS Shoup transmissions (Fromm, 2009; National Marine Fisheries Service, 2005; U.S. Department of the Navy, 2003) estimated a mean received SPL of approximately 169 dB re 1 µPa at the location of the killer whales at the closest point of approach between the animals and the vessel (estimated SPLs ranged from 150 to 180 dB re 1 µPa). However, attributing the observed behaviors to any one cause is problematic given there were six nearby whale watch vessels surrounding the pod, and subsequent research has demonstrated that "Southern Residents modify their behavior by increasing surface activity (breaches, tail slaps, and pectoral fin slaps) and swimming in more erratic paths when vessels are close" (National Oceanic and Atmospheric Administration Fisheries, 2014). Several odontocete species, including bottlenose dolphins, Risso's dolphins, Pacific white-sided dolphins, and common dolphins have been observed near the Southern California Offshore Range during periods of mid-frequency active sonar; responses included changes in or cessation of vocalizations, changes in behavior, and departures from the area, and at the highest received levels animals were not present in the area at all (Henderson et al., 2014). However, these observations were conducted from a vessel off-range, and so any observed responses could not be attributed to the sonar with any certainty. Research on sperm whales in the Caribbean in 1983 coincided with the U.S. intervention in Grenada, where animals were observed scattering and leaving the area in the presence of military sonar, presumably from nearby submarines (Watkins & Schevill, 1975; Watkins et al., 1985). The authors did not report received levels from these exposures and reported similar reactions from noise generated by banging on their boat hull; therefore, it was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general.

During aerial and visual monitoring of Navy training events involving sonar, rough-toothed dolphins and unidentified dolphins were observed approaching the vessel with active sonar as if to bow ride, while spotted dolphins were observed nearby but did not avoid or approach the vessel (Mobley, 2011; U.S. Department of the Navy, 2011b; Watwood et al., 2012). During small boat surveys near the Southern California Offshore Range in southern California, more dolphins were encountered in June compared to a similar survey conducted the previous November after seven days of mid-frequency sonar activity; it was not investigated if this change was due to the sonar activity or was a seasonal difference that was also observed in other years (Campbell et al., 2010). There were also fewer passive acoustic dolphin detections during and after longer sonar activities in the Mariana Islands Range Complex, with the post-activity absence lasting longer than the mean dolphin absence of two days when sonar was not present (Munger et al., 2014; Munger et al., 2015).

Acoustic harassment devices and acoustic deterrent devices, that transmit sound into the acoustic environment similar to Navy sonar, have been used to deter marine mammals from fishing gear both to prevent entanglement and to reduce depredation (taking fish). These devices have been used successfully to deter harbor porpoises and beaked whales from getting entangled in fishing nets. For example, Kyhn et al. (2015) tested two types of pingers, one with a 10 kHz tone and one with a broadband 30–160 kHz sweep. Porpoise detection rates were reduced by 65 percent for the sweep and 40 percent for the tone, and while there was some gradual habituation after the first two to four exposures, longer-term exposures (over 28 days) showed no evidence of additional habituation. Additionally, sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins & Schevill, 1975). However, acoustic harassment devices used to deter marine mammals from depredating long lines or aquaculture enclosures have proven less successful. For example, Tixier et al. (2014) used a 6.5 kHz pinger with a source level of 195 dB re 1 µPa on a longline to prevent depredation by killer whales, and although two groups of killer whales fled over 700 m away during the first exposure, they began depredating again after the third and seventh exposures, indicating rapid habituation. In a review of marine mammal deterrents, Schakner & Blumstein (2013) point out that both the characteristics of deterrents and the motivation of the animal play a role in the effectiveness of acoustic harassment devices. Deterrents that are strongly aversive or simulate a predator or are otherwise predictive of a threat are more likely to be effective, unless the animal habituates to the signal or learns that there is no true threat associated with the signal. In some cases net pingers may create a "dinner bell effect," where marine mammals have learned to associate the signal with the availability of prey (Jefferson & Curry, 1996; Schakner & Blumstein, 2013). This may be why net pingers have been more successful at reducing entanglements for harbor porpoise and beaked whales since these species are not depredating from the nets but are getting entangled when foraging in the area and are unable to detect the net (Carretta et al., 2008; Schakner & Blumstein, 2013). Similarly, a 12 kHz acoustic harassment device intended to scare seals was ineffective at deterring seals but effectively caused avoidance in harbor porpoises out to over 500 m from the source, highlighting different species- and device-specific responses (Mikkelsen et al., 2017). Additional behavioral studies have been conducted with captive harbor porpoises using acoustic alarms, such as those used on fishing nets to help deter marine mammals from becoming caught or entangled (Kastelein et al., 2006; Kastelein et al., 2001). These studies have found that high-frequency sources with varied duration, interval, and sweep characteristics can prove to be effective deterrents for harbor porpoises (Kastelein et al., 2017). Van Beest et al. (2017) modeled the long-term, population-level impacts of fisheries bycatch, pinger deterrents, and time-area closures on a population of harbor porpoises. They found that when pingers were used alone (in the absence of gillnets or time-area closures), the animals were deterred from the area often enough to cause a population level reduction of 21 percent, greater even than the modeled level of current bycatch impacts. However, when the pingers were coupled with gillnets in the model, and time-area closures were also used (allowing a net- and pinger-free area for the porpoises to move into while foraging), the population only experienced a 0.8 percent decline even with current gillnet use levels. This demonstrates that, when used correctly, pingers can successfully deter porpoises from gillnets without leading to any negative impacts.

Controlled experiments have also been conducted on captive animals to estimate received levels at which behavioral responses occur. In one study, bottlenose dolphin behavioral responses were recorded when exposed to 3 kHz sonar-like tones between 115 and 185 dB re 1 μPa (Houser et al., 2013), and in another study bottlenose dolphins and beluga whales were presented with one-second tones up to 203 dB re 1 μPa to measure TTS (Finneran et al., 2001; Finneran et al., 2003a; Finneran & Schlundt, 2004; Finneran et al., 2005b; Schlundt et al., 2000). During these studies, responses included changes in respiration rate, fluke slaps, and a refusal to participate or return to the location 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 (Finneran et al., 2002; Schlundt et al., 2000). In the behavioral response experiment, bottlenose dolphins demonstrated a 50 percent probability of response at 172 dB re 1 μPa over 10 trials, and in the TTS study bottlenose dolphins exposed to one-second intense tones exhibited short-term changes in behavior above received sound levels of 178–193 dB re 1 μPa, while 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 animals were commonly reinforced with food during these studies, the controlled environment and ability to measure received levels provide insight on received levels at which animals would behaviorally respond to noise sources.

Behavioral responses to a variety of sound sources have been studied in captive harbor porpoises, including acoustic alarms (Kastelein et al., 2006; Kastelein et al., 2001); emissions for underwater data transmission (Kastelein et al., 2005); and tones, including 1–2 kHz and 6–7 kHz sweeps with and without harmonics (Kastelein et al., 2014d), 25 kHz with and without sidebands (Kastelein et al., 2015d; Kastelein et al., 2015e), and mid-frequency sonar tones at 3.5–4.1 kHz at 2.7 percent and 96 percent duty cycles (e.g., one tone per minute versus a continuous tone for almost a minute) (Kastelein et al., 2018). Responses include increased respiration rates, more jumping, or swimming further from the source, but responses were different depending on the source. For example, harbor porpoises responded to the 1–2 kHz upsweep at 123 dB re 1 μPa, but not to the downsweep or the 6–7 kHz tonal at the same level (Kastelein et al., 2014d). When measuring the same sweeps for a startle response, the 50 percent response threshold was 133 and 101 dB re 1 μPa for 1–2 kHz and 6–7 kHz sweeps, respectively, when no harmonics were present, and decreased to 90 dB re 1 μPa for 1–2 kHz sweeps with harmonics present (Kastelein et al., 2014d). Harbor porpoises did not respond to the low-duty cycle mid-frequency tones at any received level, but one did respond to the high-duty cycle signal with more jumping and increased respiration rates (Kastelein et al., 2018). Harbor porpoises responded to seal scarers with broadband signals up to 44 kHz with a slight respiration response at 117 dB re 1 μPa and an avoidance response at 139 dB re 1 μPa, but another scarer with a fundamental (strongest) frequency of 18 kHz did not have an avoidance response until 151 dB re 1 μPa (Kastelein et al., 2014a). Exposure of the same acoustic pinger to a striped dolphin under the same conditions did not elicit a response (Kastelein et al., 2006), again highlighting the importance in understanding species differences in the tolerance of underwater noise, although sample sizes in these studies was small so these could reflect individual differences as well.

Behavioral responses by odontocetes to sonar and other transducers appear to range from no response at all to responses that could potentially lead to long-term consequences for individual animals (e.g., mother-calf separation). This is likely in part due to the fact that this taxonomic group is so broad and includes some of the most sensitive species (e.g., beaked whales and harbor porpoise) as well as some of the least sensitive species (e.g., bottlenose dolphins). This is also the only group for which both field behavioral response studies and captive controlled exposure experiments have been conducted, leading to the assessment of both contextually driven responses as well as dose-based responses. This wide range in both exposure situations and individual- and species-sensitivities makes reaching general conclusions difficult. However, it does appear as though exposures in close proximity, with multiple vessels that approach the animal, lead to higher-level responses in most odontocete species regardless of received level or behavioral state. In contrast, in more “real-world” exposure situations, with distant sources moving in variable directions, behavioral responses appear to be driven by behavioral state, individual experience, or species-level sensitivities. These responses may also occur more in line with received level such that the likelihood of a response would increase with increased received levels. However, these “real-world” responses are more likely to be short-term, lasting the duration of the exposure or even shorter as the animal assesses the sound and (based on prior experience or contextual cues) determines a threat is unlikely. Therefore, while odontocete behavioral responses to Navy sonar would vary across species, populations, and individuals, they are not likely to lead to long-term consequences or population-level effects.

Behavioral Reactions to Vessels

Sound emitted from large vessels, such as cargo 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 (Hatch & Wright, 2007; Hildebrand, 2005; Richardson et al., 1995b). For example, Erbe et al. (2012) estimated the maximum annual underwater SEL from vessel traffic near Seattle was 215 dB re 1 µPa^2-s, and Bassett et al. (2010) measured mean SPLs at Admiralty Inlet from commercial shipping at 117 dB re 1 µPa with a maximum exceeding 135 dB re 1 µPa on some occasions. Similarly, Veirs et al. (2015) found average broadband noise levels in Haro Strait to be 110 dB re 1 µPa that extended up to 40 kHz, well into the hearing range of odontocetes.

Many studies of behavioral responses by marine mammals to vessels have been focused on the short- and long-term impacts of whale watching vessels. In short-term studies, researchers noted changes in resting and surface behavior states of cetaceans to whale-watching vessels (Acevedo, 1991; Aguilar de Soto et al., 2006; Arcangeli & Crosti, 2009; Au & Green, 2000; Christiansen et al., 2010; Erbe, 2002; Noren et al., 2009; Stockin et al., 2008; Williams et al., 2009). Received levels were often not reported, so it is difficult to distinguish responses to the presence of the vessel from responses to the vessel noise. Most studies examined the short-term response to vessel sound and vessel traffic (Magalhães et al., 2002; Richardson et al., 1995b; Watkins, 1981), with behavioral and vocal responses occurring when received levels were over 20 dB greater than ambient noise levels. Other research has attempted to quantify the effects of whale watching using focused experiments (Meissner et al., 2015; Pirotta et al., 2015b).

The impact of vessel noise has received increased consideration, particularly as whale watching and shipping traffic has risen (McKenna et al., 2012; Pirotta et al., 2015b; Veirs et al., 2015). Odontocetes and mysticetes in particular have received increased attention relative to vessel noise and vessel traffic, with pinnipeds less so. Still, not all species in all taxonomic groups have been studied, and so results do have to be extrapolated across these broad categories in order to assess potential impacts.

Mysticetes

Baleen whales demonstrate a variety of responses to vessel traffic and noise, from not responding at all to both horizontal (swimming away) and vertical (increased diving) avoidance (Baker et al., 1983; Gende et al., 2011; Watkins, 1981). Other common responses include changes in vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au & Green, 2000; Richter et al., 2003; Williams et al., 2002a).

The likelihood of response may be driven by the distance or speed of the vessel, the animal's behavioral state, or by the prior experience of the individual or population. For example, in one study fin and humpback whales largely ignored vessels that remained 100 m or more away (Watkins, 1981). In another study, minke whales in the Antarctic did not show any apparent response to a survey vessel moving at normal cruising speeds (about 12 knots) at a distance of 5.5 NM. However, when the vessel drifted or moved at very slow speeds (about 1 knot), many whales approached it (Leatherwood et al., 1982). Similarly, Bernasconi et al. (2012) observed the reactions of six individual baleen whales of unknown species at distances of 50–400 m from a fishing vessel conducting an acoustic survey of pelagic fisheries, with only a slight change in swim direction when the vessel began moving around the whales. Gray whales were likely to continue feeding when approached by a vessel in areas with high motorized vessel traffic, but in areas with less motorized vessel traffic they were more likely to change behaviors, either indicating habituation to vessels in high traffic area, or indicating possible startle reactions to close-approaching non-motorized vessels (e.g., kayaks) in quieter areas (Sullivan & Torres, 2018). Changes in behavior of humpback whales when vessels came within 500 m were also dependent on behavioral state such that they would keep feeding but were more likely to start traveling if they were surface active when approached; and changes in behavior were also affected by time of day or season (Di Clemente et al., 2018). Sei whales have been observed ignoring the presence of vessels entirely and even passing close to the vessel (Reeves et al., 1998), and North Atlantic right whales tend not to respond to the sounds of oncoming vessels and continue to use habitats in high vessel traffic areas (Nowacek et al., 2004). Studies show that North Atlantic right whales demonstrate little if any reaction to sounds of vessels approaching or the presence of the vessels themselves. This lack of response may be due to habituation to the presence and associated noise of vessels in right whale habitat, or may be due to propagation effects that may attenuate vessel noise near the surface (Nowacek et al., 2004; Terhune & Verboom, 1999).

When baleen whales do respond to vessels, responses can be as minor as a change in breathing patterns (e.g., Baker et al., 1983; Jahoda et al., 2003), or can be evidenced by a decrease in overall presence, as was observed during a construction project in the United Kingdom, when fewer minke whales were observed as vessel traffic increased (Anderwald et al., 2013). Avoidance responses can be as simple as an alteration in swim patterns or direction by increasing speed and heading away from the vessel (Jahoda et al., 2003), or by increasing swim speed, changing direction to avoid, and staying submerged for longer periods of time (Au & Green, 2000). For example, 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., 2009b). In another study in Hawaii, humpback whales exhibited two forms of behavioral avoidance: horizontal avoidance (changing direction or speed) when vessels were between 2,000 m and 4,000 m away, and vertical avoidance (increased dive times and change in diving pattern) when vessels were less than 2,000 m away (Baker et al., 1983). Similarly, humpback whales in Australia demonstrated variable responses to whale watching vessels, including both horizontal avoidance, approaching, and changes in dive and surface behavior (Stamation et al., 2009). Humpback whales avoided a Navy vessel by increasing their dive times and decreasing respiration rates at the surface (Smultea et al., 2009). Williamson et al. (2016) specifically looked at close approaches to humpback whales by small research boats for the purposes of tagging. They found that while dive behavior did not change for any groups, some groups did increase their speed and change their course during or right after the approach, but resumed pre-approach speed and heading shortly thereafter. Only mother-calf groups were found to increase their speed during the approach and maintain the increased speed for longer after the approach, but these groups too resumed normal swim speeds after about 40 minutes. It should be noted that there were no responses by any groups that were approached closely but with no attempts at tagging, indicating that the responses were not due to the vessel presence but to the tagging attempt. In addition, none of the observed changes in behavior were outside the normal range of swim speeds or headings for these migrating whales.

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. 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. An increase in feeding call rates and repetition by humpback whales in Alaskan waters is associated with vessel noise (Doyle et al., 2008), while decreases in singing activity have been noted near Brazil due to boat traffic (Sousa-Lima & Clark, 2008). Frequency parameters of fin whale calls also decreased in the presence of increasing background noise due to shipping traffic (Castellote et al., 2012). Bowhead whales avoided the area around icebreaker ship noise and increased their time at the surface and number of blows (Richardson et al., 1995a). Right whales increase the amplitude or frequency of their vocalizations or call at a lower rate in the presence of increased vessel noise (Parks et al., 2007; Parks et al., 2011), and these vocalization changes may persist over long periods if background noise levels remained elevated.

The long-term consequences of vessel noise are not well understood (see Section 3.4.2.1.1.7, Long-Term Consequences). In a short-term study, minke whales on feeding grounds in Iceland responded to increased whale-watching vessel traffic with a decrease in foraging, both during deep dives and at the surface (Christiansen et al., 2013). They also increased their avoidance of the boats while decreasing their respiration rates, likely leading to an increase in their metabolic rates. Christiansen and Lusseau (2015) and Christiansen et al. (2014) followed up this study by modeling the cumulative impacts of whale-watching boats on minke whales, but found that although the boats cause temporary feeding disruptions, there were not likely to be long-term consequences as a result. This suggests that short-term responses may not lead to long-term consequences and that over time animals may habituate to the presence of vessel traffic. However, in an area of high whale-watch activity, vessels were within 2,000 m of blue whales 70 percent of the time, with a maximum of eight vessels observed within 400 m of one whale at the same time. This study found reduced surface time, fewer breaths at the surface, and shorter dive times when vessels were within 400 m (Lesage et al., 2017). Since blue whales in this area forage 68 percent of the time, and their foraging dive depths are constrained by the location of prey patches, these reduced dive durations may indicate reduced time spent foraging by over 36 percent. In the short term this reduction may be compensated for, but prolonged exposure to vessel traffic could lead to long-term consequences. 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 towards the boat or research equipment to investigate, to more uninterested reactions towards the end of the study. 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 reactions (ignoring) allowing boats to approach within 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).

Overall baleen whale responses to vessel noise and traffic are varied but are generally minor, and habituation or disinterest seems to be the predominant long-term response. When baleen whales do avoid ships they do so by altering their swim and dive patterns to move away from the vessel, but no strong reactions have been observed. In fact, in many cases the whales do not appear to change their behavior at all. This may result from habituation by the whales, but may also result from reduced received levels near the surface due to propagation, or due to acoustic shadowing of the propeller cavitation noise by the ship’s hull. Although a lack of response in the presence of a vessel may minimize potential disturbance from passing ships, it does increase the whales’ vulnerability to vessel strike, which may be of greater concern for baleen whales than vessel noise (see Section 3.4.4.4, Physical Disturbance and Strike Stressors in the 2015 MITT Final EIS/OEIS).

Odontocetes

Most odontocetes react neutrally to vessels, although both avoidance and attraction behavior have been observed (Hewitt, 1985; Würsig et al., 1998). Würsig et al. (1998) found that Kogia whales and beaked whales were the most sensitive species to vessels, and reacted by avoiding marine mammal survey vessels in 73 percent of sightings, more than any other odontocetes. Avoidance reactions include a decrease in resting behavior or change in travel direction (Bejder et al., 2006a). Incidents of attraction include common, rough-toothed, and bottlenose dolphins bow riding and jumping in the wake of a vessel (Norris & 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., 2010). The presence of vessels has also been shown to interrupt feeding behavior in delphinids (Meissner et al., 2015; Pirotta et al., 2015b).

Short-term displacement of dolphins due to tourist boat presence has been documented (Carrera et al., 2008), while longer-term or repetitive/chronic displacement for some dolphin groups due to chronic vessel noise has been noted (Haviland-Howell et al., 2007). Delphinid behavioral states also change in the presence of tourist boats that often approach animals, with travel increasing and foraging decreasing (Cecchetti et al., 2017; Meissner et al., 2015). 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 (Acevedo, 1991; Arcangeli & Crosti, 2009; Berrow & Holmes, 1999; Gregory & Rowden, 2001; Janik & Thompson, 1996; Lusseau, 2004; Mattson et al., 2005; Scarpaci et al., 2000). Steckenreuter (2011) found bottlenose dolphin groups to feed less, become more tightly clustered, and have more directed movement when approached to 50 m than groups approached to 150 m or approached in a controlled manner. 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 also found the dolphins' reactions varied depending on whether the observing research vessel was approaching or moving away from the animals being observed. This demonstrates that the influence of the sound exposure cannot be decoupled from the physical presence of a surface vessel, thus complicating interpretations of the relative contribution of each stimulus to the response. Indeed, the presence of surface vessels, their approach, and speed of approach, seemed to be significant factors in the response of the Indo-Pacific humpback dolphins (Ng & Leung, 2003).

The effects of tourism and whale watching have highly impacted killer whales, such as the Northern and Southern Resident populations. These animals are targeted by numerous small whale-watching vessels in the Pacific Northwest and, from 1998 to 2012 during the viewing season, have had an annual monthly average of nearly 20 vessels of various types within 0.5 mile of their location during daytime hours (Clark, 2015; Eisenhardt, 2014; Erbe et al., 2014). These vessels have source levels that ranged from 145 to 169 dB re 1 µPa and produce broadband noise up to 96 kHz and 116 dB re 1 µPa. While new regulations on the distance boats had to maintain were implemented, there did not seem to be a concurrent reduction in the received levels of vessel noise, and noise levels were found to increase with more vessels and faster-moving vessels (Holt et al., 2017). These noise levels have the potential to result in behavioral disturbance, interfere with communication, and affect the killer whales' hearing capabilities via masking (Erbe, 2002; Veirs et al., 2015). Killer whales foraged significantly less and traveled significantly more when boats were within 100 m of the whales (Kruse, 1991; Lusseau et al., 2009; Trites & Bain, 2000; Williams et al., 2002a; Williams et al., 2002b; 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). As with other delphinids, 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. Williams et al. (2013) modeled behavioral responses of killer whales to vessel traffic by looking at their surface behavior relative to the received level of three large classes of ships. The authors found that the severity of the response was largely dependent on seasonal data (e.g., year and month) as well as the animal's prior experience with vessels (e.g., age and sex), and the number of other vessels present, rather than the received level of the larger ships (Williams et al., 2013).

Sperm whales generally react only to vessels approaching within several hundred meters; however, some individuals may display avoidance behavior, such as quick diving (Magalhães et al., 2002; Würsig et al., 1998) or a decrease in time spent at the surface (Isojunno & Miller, 2015). One study showed that after diving, sperm whales showed a reduced timeframe before they emitted the first click than prior to a vessel interaction (Richter et al., 2006). 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 an individual whale. Azzara et al. (2013) also found a reduction in sperm whale clicks while a vessel was passing, as well as up to a half hour after the vessel had passed. It is unknown whether the whales left the area, ceased to click, or surfaced during this period. However, some of the reduction in click detections may be due to masking of the clicks by the vessel noise, particularly during the closest point of approach.

Little information is available on the behavioral impacts of vessels or vessel noise on beaked whales (Cox et al., 2006), although it seems most beaked whales react negatively to vessels by quick diving and other avoidance maneuvers (Würsig et al., 1998). Limited evidence suggests that beaked whales respond to vessel noise, anthropogenic noise in general, and mid-frequency sonar at similar sound levels (Aguilar de Soto et al., 2006; Tyack et al., 2011; Tyack, 2009). An observation of vocal disruption of a foraging dive by a Cuvier's beaked whale when a large, noisy vessel passed suggests that some types of vessel traffic may disturb foraging beaked whales (Aguilar de Soto et al., 2006). Tyack et al. (2011) noted the result of a controlled exposure to pseudorandom noise suggests that beaked whales would respond to vessel noise at similar received levels to those noted previously for mid-frequency sonar. Pirotta et al. (2012) found that while the distance to a vessel did not change the duration of a foraging dive, the proximity of the vessel may have restricted the movement of the group. The maximum distance at which this change was significant was 5.2 km, with an estimated received level of 135 dB re 1 µPa.

Small dolphins and porpoises may also be more sensitive to vessel noise. Both finless porpoises (Li et al., 2008) and harbor porpoises (Polacheck & Thorpe, 1990) routinely avoid and swim away from large motorized vessels, and harbor porpoises may click less when near large ships (Sairanen, 2014). A resident population of harbor porpoise in Swansea Bay are regularly near vessel traffic, but only 2 percent of observed vessels had interactions with porpoises in one study (Oakley et al., 2017). Of these, 74 percent of the interactions were neutral (no response by the porpoises) while vessels were 10 m–1 km away. Of the 26 percent of interactions in which there was an avoidance response, most were observed in groups of 1–2 animals to fast-moving or steady plane-hulling motorized vessels. Larger groups reacted less often, and few responses were observed to non-motorized or stationary vessels. Another study found that when vessels were within 50 m, harbor porpoises had an 80 percent probability of changing their swimming direction when vessels were fast moving; this dropped to 40 percent probability when vessels were beyond 400 m (Akkaya Bas et al., 2017). These porpoises also demonstrated a reduced proportion of feeding and shorter behavioral bout durations in general, if vessels were in close proximity, 62 percent of the time. Although most vessel noise is constrained to lower frequencies below 1 kHz, at close range vessel noise can extend into mid- and high-frequencies (into the tens of kHz) (Hermannsen et al., 2014; Li et al., 2015); these frequencies are what harbor porpoises are likely responding to, at M-weighted received SPLs with a mean of 123 dB re 1 µPa (Dyndo et al., 2015). Foraging harbor porpoises also have fewer prey capture attempts and have disrupted foraging when vessels pass closely and noise levels are higher (Wisniewska et al., 2018).

Odontocetes have been shown to make short-term changes to vocal parameters such as intensity as an immediate response to vessel noise, as well as to increase the pitch, frequency modulation, and length of whistling (May-Collado & Wartzok, 2008), with whistle frequency increasing in the presence of low-frequency noise and whistle frequency decreasing in the presence of high-frequency noise (Gospić & Picciulin, 2016). For example, bottlenose dolphins in Portuguese waters decrease their call rates and change the frequency parameters of whistles in the presence of boats (Luís et al., 2014), while dolphin groups with calves increase their whistle rates when tourist boats are within 200 m and when the boats increase their speed (Guerra et al., 2014). Likewise, modification of multiple vocalization parameters was 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., 2011). 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 in 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 is suggested as being a long-term response to increased masking noise produced by the vessels (Foote et al., 2004).

The long-term and cumulative implications of ship sound on odontocetes is largely unknown (National Academies of Sciences Engineering and Medicine, 2017; National Marine Fisheries Service, 2007a), although some long-term consequences have been reported (Lusseau & Bejder, 2007). 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 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. (2006a) 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.

Similar to mysticetes, odontocete responses to vessel noise are varied, although many odontocete species seem to be more sensitive to vessel presence and vessel noise, and these two factors are difficult to tease apart. Some species, in particular killer whales and porpoises, may be sensitized to vessels and respond at further distances and lower received levels than other delphinids. In contrast, many odontocete species also approach vessels to bow ride, indicating either that these species are less sensitive to vessels, or that the behavioral drive to bow ride supersedes any impact of the associated noise. With these broad and disparate responses, it is difficult to assess the impacts of vessel noise on odontocetes.

Behavioral Reactions to Aircraft Noise

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 and rotary-wing aircraft (i.e., helicopters), as well as unmanned aerial systems. Thorough reviews of the subject and available information is presented in Richardson et al. (1995b) and elsewhere (e.g., Efroymson et al., 2001; Holst et al., 2011; Luksenburg & Parsons, 2009; Smith et al., 2016). The most common responses of cetaceans to overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping) (Nowacek et al., 2007a). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Holst et al., 2011; Manci et al., 1988). Richardson et al. (1995b) 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 overflights (Richardson et al., 1995b). These factors could include aircraft type (e.g., single engine, multi engine, jet turbine), flight path (altitude, centered on the animal, off to one side, circling, level and slow), environmental factors (e.g., wind speed, sea state, cloud cover), and locations where native subsistence hunting continues and animals are more sensitive to anthropogenic impacts, including the noise from aircraft. Christiansen et al. (2016b) measured the in-air and underwater noise levels of two unmanned aerial vehicles, and found that in-air the broadband source levels were around 80 dB re 20 µPa, while at a meter underwater received levels were 95–100 dB re 1 µPa when the vehicle was only 5–10 m above the surface, and were not quantifiable above ambient noise levels when the vehicle was higher. Therefore, if an animal is near the surface and the unmanned aerial vehicle is low, it may be detected, but in most cases these vehicles are operated at much higher altitudes (e.g., over 30 m) and so are not likely to be heard.

The impact of aircraft overflights is one of the least well-known sources of potential behavioral response by any species or taxonomic group, and so many generalities must be made based on the little data available. There is some data for each taxonomic group; taken together it appears that in general, marine mammals have varying levels of sensitivity to overflights depending on the species and context.

Mysticetes

Mysticetes either ignore or occasionally dive in response to aircraft overflights (Koski et al., 1998). Richardson (1985; 1995b) found no evidence that single or occasional aircraft flying above mysticetes causes long-term displacement of these mammals.

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. (304.8 m.) above sea level, infrequently observed at 1,500 ft. (457.2 m.), and not observed at all at 2,000 ft. (609.6 m.) (Richardson et al., 1985). 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 150 m or higher. The bowheads exhibited fewer behavioral changes than did the odontocetes in the same area (Patenaude et al., 2002). It should be noted that bowhead whales in this study may have more acute responses to anthropogenic activity than many other marine mammals since these animals were presented with restricted egress due to limited open water between ice floes. Additionally, these animals are hunted by Alaska Natives, which could lead to animals developing additional sensitivity to human noise and presence.

A pilot study was conducted on the use of unmanned aerial systems to observe bowhead whales; flying at altitudes between 120 and 210 m above the surface, no behavioral responses were observed in any animals (Koski et al., 1998; Koski et al., 2015). Similarly, Christiansen et al. (2016a) did not observe any responses to an unmanned aerial vehicle flown 30–120 m above the water when taking photos of humpback whales to conduct photogrammetry and assess fitness. Acevedo-Whitehouse et al. (2010) successfully maneuvered a remote-controlled helicopter over large baleen whales to collect samples of their blows, with no more avoidance behavior than noted for typical photo-identification vessel approaches. These vehicles are much smaller and quieter than typical aircraft and so are less likely to cause a behavioral response, although they may fly at much lower altitudes (Smith et al., 2016).

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., 1995b). Würsig et al. (1998) found that beaked whales were the most sensitive cetacean and reacted by avoiding marine mammal survey aircraft in 89 percent of sightings and at more than twice the rate as Kogia whales, which was the next-most reactive of the odontocetes in 39 percent of sightings; these are the same species that were sensitive to vessel traffic.

During standard marine mammal surveys at an altitude of 750 ft., 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; Richter et al., 2003; Richter et al., 2006; 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., 1995b). A group of sperm whales responded to a circling aircraft (altitude of 800 to 1,100 ft.) 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). Whale-watching aircraft (fixed-wing airplanes and helicopters) apparently caused sperm whales to turn more sharply but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al., 2003).

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 whales and beaked whales) show similar reactions to aircraft (Würsig et al., 1998). Beluga whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns to a greater extent than mysticetes in the same area (Patenaude et al., 2002). These reactions increased in frequency as the altitude of the helicopter dropped below 150 m. A change in travel direction was noted in a group of pilot whales as the aircraft circled while conducting monitoring (State of Hawaii, 2015).

Much like mysticetes, odontocetes have demonstrated no responses to unmanned aerial systems. For example, Durban et al. (2015) conducted photogrammetry studies of killer whales using a small helicopter flown 35–40 m above the animals with no disturbance noted. However, odontocete responses may increase with reduced altitude, due either to noise or the shadows created by the vehicle (Smith et al., 2016). Bottlenose dolphins responded to a small portion of unmanned aerial vehicles by briefly orienting when the vehicle was relatively close (10–30 m high), but in most cases didn't respond at all (Ramos et al., 2018).

3.4.2.1.1.6 Stranding

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 (Geraci et al., 1999; Geraci & Lounsbury, 2005). When a marine mammal (alive or dead) 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 & Lounsbury, 2005; Perrin & Geraci, 2002). A stranding can also occur away from the shore if the animal is unable to cope in its present situation (e.g., disabled by a vessel strike, out of habitat) (Geraci & Lounsbury, 2005). Specifically, under U.S. law, a stranding is an event in the wild in which: "(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 U.S.C. section 1421h).

Natural factors related to strandings include limited food availability or following prey inshore, predation, disease, parasitism, natural toxins, echolocation disturbance, climatic influences, and aging (Bradshaw et al., 2006; Culik, 2004; Geraci et al., 1999; Geraci & Lounsbury, 2005; Huggins et al., 2015; National Research Council, 2006; Perrin & Geraci, 2002; Walker et al., 2005). Anthropogenic factors include pollution (Hall et al., 2006; Jepson et al., 2005), vessel strike (Geraci & Lounsbury, 2005; Laist et al., 2001), fisheries interactions (Read et al., 2006), entanglement (Baird & Gorgone, 2005; Saez et al., 2012; Saez et al., 2013), human activities (e.g., feeding, gunshot) (Geraci & Lounsbury, 2005; Dierauf & Gulland, 2001), and noise (Cox et al., 2006; National Research Council, 2003; Richardson et al., 1995b). For some stranding events, environmental factors (e.g., ocean temperature and wind speed and geographic conditions) can be utilized in predictive models to aid in understanding why marine mammals strand in certain areas more than others (Berini et al., 2015). In most instances, even for the more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for strandings remains undetermined.

Several mass strandings (strandings that involve two or more individuals of the same species, excluding a single mother-calf pair) that have occurred over the past two decades have been associated with anthropogenic activities that introduced sound into the marine environment, such as naval operations and seismic surveys. An in-depth discussion of strandings is in the Navy's technical report titled *Marine Mammal Strandings Associated with U.S. Navy Sonar Activities* (U.S. Department of the Navy, 2017c).

Sonar use during exercises involving the U.S. Navy 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 (Cox et al., 2006; Fernandez, 2006; U.S. Department of the Navy, 2017c). These five mass strandings resulted in about 40 known cetacean deaths consisting mostly of beaked whales and with close linkages to mid-frequency active sonar activity. In these circumstances, exposure to non-impulsive acoustic energy was considered a possible indirect cause of death of the marine mammals (Cox et al., 2006). Strandings of other marine mammal species have not been as closely linked to sonar exposure, but rather, have typically been attributed to natural or other anthropogenic factors. The Navy has reviewed training requirements, standard operating procedures, and potential mitigation measures, and has implemented changes to reduce the potential for acoustic related strandings to occur in the future. Discussions of procedures associated with these and other training and testing events are presented in Chapter 5 (Mitigation).

Multiple hypotheses regarding the relationship between non-impulsive sound exposure and stranding have been proposed. These range from direct impact of the sound on the physiology of the marine mammal, to behavioral reactions contributing to altered physiology (e.g., "gas and fat embolic syndrome") (Fernandez et al., 2005; Jepson et al., 2003; Jepson et al., 2005), to behaviors directly contributing to the stranding (e.g., beaching of fleeing animals). Unfortunately, without direct observation of not only the event but also the underlying process, and given the potential for artefactual evidence (e.g., chronic condition, previous injury) to complicate conclusions from the post-mortem analyses of stranded animals (Cox et al., 2006), it has not been possible to determine with certainty the exact mechanism underlying these strandings.

Historically, stranding reporting and response efforts have been inconsistent, although they have improved considerably over the last 25 years. Although reporting forms have been standardized nationally, data collection methods, assessment methods, detail of reporting and procedures vary by region and are not yet standardized across the United States. Conditions such as weather, time, location, and decomposition state may also affect the ability to thoroughly examine a specimen (Carretta et al., 2016b; Moore et al., 2013). Because of this, the current ability to interpret long-term trends in marine mammal stranding is limited. While the investigation of stranded animals provides insight into the types of threats marine mammal populations face, investigations are only conducted on a small fraction of the total number of strandings that occur, limiting our understanding of the causes of strandings (Carretta et al., 2016a). Although many marine mammals likely strand due to natural or anthropogenic causes, the majority of reported type of occurrences in marine mammal strandings in the Pacific include fisheries interactions, entanglement, vessel strike, and predation (Carretta et al., 2017b; Helker et al., 2017).

3.4.2.1.1.7 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. Physical effects that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions and short-term or chronic instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. For example, a lost reproductive opportunity could be a measurable cost to the individual, or for very small populations to the population as a whole; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences. It is more likely that any long-term consequences to an individual would be a result of costs accumulated over a season, year, or life stage due to multiple behavioral or stress responses resulting from exposure to many sound-producing activities over significant periods.

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 (Wartzok et al., 2003). Highly resident or localized populations may also stay in an area of disturbance because the cost of displacement may be higher than the cost of remaining (Forney et al., 2017). Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region (Bejder et al., 2006b; Blackwell et al., 2004; Teilmann et al., 2006). Gray whales in Baja California abandoned a historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. However, whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al., 1984). 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. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found 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.

Moore and Barlow (2013) noted a decline in the overall beaked whale population in a broad area of the Pacific Ocean along the U.S. West Coast. Moore and Barlow (2013) provide several hypotheses for the decline of beaked whales in those waters, one of which is anthropogenic sound including the use of sonar by the U.S. Navy; however, new data have been published that raise uncertainties over whether a decline in the beaked whale population occurred off the U.S. West Coast between 1996 and 2014 (Barlow, 2016). Moore and Barlow (2017) have since incorporated information from the entire 1991 to 2014 time series, which suggests an increasing abundance trend and a reversal of the declining trend along the U.S. West Coast that had been noted in their previous (2013) analysis.

In addition, studies on the Atlantic Undersea Test and Evaluation Center instrumented range in the Bahamas have shown that some Blainville's beaked whales may be resident during all or part of the year in the area. Individuals may move off the range for several days during and following a sonar event, but return within a few days (McCarthy et al., 2011; Tyack et al., 2011). Photo-identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years and re-sightings up to seven years apart (Falcone et al., 2009; Falcone & Schorr, 2014). These results indicate long-term residency by individuals in an intensively used Navy training and testing area, which may suggest a lack of long-term consequences as a result of exposure to Navy training and testing activities, but could also be indicative of high-value resources that exceed the cost of remaining in the area. Long-term residency does not mean there has been no impact on population growth rates, and there are no data existing on the reproductive rates of populations inhabiting the Navy range area around San Clemente Island as opposed to beaked whales from other areas. In that regard however, recent results from photo-identifications are beginning to provide critically needed calving and weaning rate data for resident animals on the Navy's Southern California range. Three adult females that had been sighted with calves in previous years were again sighted in 2016, one of these was associated with her second calf, and a fourth female that was first identified in 2015 without a calf, was sighted in 2016 with a calf (Schorr et al., 2017). Resident females documented with and without calves from year to year will provide the data for this population that can be applied to future research questions.

Research involving three tagged Cuvier's beaked whales in the Southern California Range Complex reported on by Falcone and Schorr (2012, 2014) has documented movements in excess of hundreds of kilometers by some of those animals. Schorr et al. (2014) reported the results for an additional eight tagged Cuvier's beaked whales in the same area. Five of these eight whales made journeys of approximately 250 km from their tag deployment location, and one of these five 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 (Schorr et al., 2014), temporarily leaving an area to avoid sonar or other anthropogenic activity may have little cost.

Another approach to investigating long-term consequences of anthropogenic noise exposure has been an attempt to link short-term effects to individuals from anthropogenic stressors with long-term consequences to populations using population models. 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. Unfortunately, for acoustic and explosive impacts on marine mammal populations, many of the inputs required by population models are not known. Nowacek et al. (2016) reviewed new technologies, including passive acoustic monitoring, tagging, and the use of unmanned aerial vehicles, which can improve scientists' abilities to study these model inputs and link behavioral changes to individual life functions and ultimately population-level effects. The linkage between immediate behavioral or physiological effects to an individual due to a stressor such as sound, the subsequent effects on that individual's vital rates (growth, survival, and reproduction), and in turn the consequences for the population have been reviewed in National Research Council (2005).

The Population Consequences of Acoustic Disturbance model (National Research Council, 2005) proposes a conceptual model for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population. In 2009, the U.S. Office of Naval Research set up a working group to transform the Population Consequences of Acoustic Disturbance framework into a mathematical model and include other stressors potentially causing disturbance in addition to noise. The model, now called Population Consequences of Disturbance, has been used for case studies involving bottlenose dolphins, North Atlantic right whales, beaked whales, southern elephant seals, California sea lions, blue whales, humpback whales, and harbor porpoise (Costa et al., 2016a; Costa et al., 2016b; Harwood & King, 2014; Hatch et al., 2012; King et al., 2015; McHuron et al., 2018; New et al., 2013a; New et al., 2013b; New et al., 2014; Pirotta et al., 2018). Currently, the Population Consequences of Disturbance model provides a theoretical framework and identifies types of data that would be needed to assess population-level impacts using this process. The process is complicated and provides a foundation for the type of data that is needed, which is currently lacking for many marine mammal species. Relevant data needed for improving these analytical approaches for population-level consequences resulting from disturbances will continue to be collected during projects funded by the U.S. Navy Marine Species Monitoring Program.

Costa et al. (2016a) emphasized taking into account the size of an animal's home range, whether populations are resident and non-migratory, or if they migrate over long areas and share their feeding or breeding areas with other populations. These factors, coupled with the extent, location, and duration of a disturbance can lead to markedly different impact results. For example, Costa et al. (2016a) modeled seismic surveys with different radii of impacts on the foraging grounds of Bering Sea humpback whales, West Antarctic Peninsula humpback whales, and California Current blue whales, and used data from tagged whales to determine foraging locations and effort on those grounds. They found that for the blue whales and the West Antarctic humpback whales, less than 19 percent and 16 percent (respectively) of each population would be exposed, and less than 19 percent and 6 percent (respectively) of foraging behavior would be disturbed. This was likely due to the fact that these populations forage for krill over large areas. In contrast, the Bering Sea population of humpback whales had over 90 percent of the population exposed when the disturbance zones extended beyond 50 km, but 100 percent of their foraging time would occur during an exposure when the zone was 25 km or more. These animals forage for fish over a much smaller area, thereby having a limited range for foraging that can be disturbed. Energetic costs were estimated for western gray whales that migrated to possible wintering grounds near China or to the Baja California wintering grounds of eastern gray whales versus the energetic costs of the shorter migration of eastern gray whales (Villegas-Amtmann et al., 2017). Researchers found that when the time spent on the breeding grounds was held constant for both populations, the energetic requirements for the western gray whales were estimated to be 11 percent and 15 percent greater during the migration to Baja California and China, respectively, than for the migration of eastern gray whales, and therefore this population would be more sensitive to energy lost through disturbance.

Pirotta et al. (2018) modeled one reproductive cycle of a female North Pacific blue whale, starting with leaving the breeding grounds off Baja California to begin migrating north to feeding grounds off California, and ending with her return to the breeding grounds, giving birth, and lactating. They modeled this scenario with no disturbance and found 95 percent calf recruitment, under a “normal” environmental perturbation (El Niño-Southern Oscillation) there was a very small reduction in recruitment, and under an “unprecedented” environmental change, recruitment was reduced to 69 percent. An intense, localized anthropogenic disturbance was modeled (although the duration of the event was not provided); if the animals were not allowed to leave the area they did not forage and recruitment dropped to 63 percent. However, if animals could leave the area of the disturbance then there was almost no change to the recruitment rate. Finally, a weak but broader spatial disturbance, where foraging was reduced by 50 percent, caused only a small decrease in calf recruitment to 94 percent.

Using the Population Consequences of Disturbance framework, modeling of the long-term consequences of exposure has been conducted for a variety of marine mammal species and stressors. Even when high and frequent exposure levels are included, few long-term consequences have been predicted. For example, De Silva et al. (2014) conducted a population viability analysis on the long-term impacts of pile driving and construction noise on harbor porpoises and bottlenose dolphins. Despite including the extreme and unlikely assumptions that 25 percent of animals that received PTS would die, and that behavioral displacement from an area would lead to breeding failure, the model only found short-term impacts on the population size and no long-term effects on population viability. Similarly, King et al. (2015) developed a Population Consequences of Disturbance framework using expert elicitation data on impacts from wind farms on harbor porpoises and, even under the worst-case scenarios, predicted less than a 0.5 percent decline in harbor porpoise populations. Nabe-Nelson et al. (2014) also modeled the impact of noise from wind farms on harbor porpoises and predicted that even when assuming a 10 percent reduction in population size if prey is impacted up to two days, the presence of ships and wind turbines did not deplete the population. In contrast, Heinis and De Jong (2015) used the Population Consequences of Disturbance framework to estimate impacts from both pile driving and seismic exploration on harbor porpoises and found a 23 percent decrease in population size over six years, with an increased risk for further reduction with additional disturbance days. These seemingly contradictory results demonstrate that refinements to models need to be investigated to improve consistency and interpretation of model results.

The Population Consequences of Disturbance model developed by New et al. (2013b) predicted that beaked whales require energy dense prey and high quality habitat, and that non-lethal disturbances that displace whales from that habitat could lead to long-term impacts on fecundity and survival; however, the authors were forced to use many conservative assumptions within their model since many parameters are unknown for beaked whales. As discussed above in Schorr et al. (2014), beaked whales have been tracked roaming over distances of 250 km or more, indicating that temporary displacement from a small area may not preclude finding energy dense prey or high quality habitat. Farmer et al. (2018) developed a bioenergetics framework to examine the impact of foraging disruption on body reserves of individual sperm whales. The authors examined rates of daily foraging disruption to predict the number of days to terminal starvation for various life stages, assuming exposure to seismic surveys. Mothers with calves were found to be most vulnerable to disruptions.

Another Population Consequences of Disturbance model developed in New et al. (2014) predicted elephant seal populations to be relatively robust even with a greater than 50 percent reduction in foraging trips (only a 0.4 percent population decline in the following year). McHuron et al. (2018) modeled the introduction of a generalized disturbance at different times throughout the breeding cycle of California sea lions, with the behavior response being an increase in the duration of a foraging trip by the female. Very short duration disturbances or responses led to little change, particularly if the disturbance was a single event, and changes in the timing of the event in the year had little effect. However, with even relatively short disturbances or mild responses, when a disturbance was modeled as recurring there were resulting reductions in population size and pup recruitment. Often, the effects weren't noticeable for several years, as the impacts on pup recruitment didn't affect the population until those pups were mature.

It should be noted that, in all of these models, assumptions were made and many input variables were unknown and so were estimated using available data. It is still not possible to utilize individual short-term behavioral responses to estimate long-term or population level effects.

The best assessment of long-term consequences from Navy training and testing activities will be to monitor the populations over time within the Study Area. A 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 and implemented comprehensive monitoring plans since 2009 for protected marine mammals 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 mitigation measures. The results of this long-term monitoring are now being compiled and analyzed for trends in occurrence or abundance over time (e.g., Martin et al., 2017); preliminary results of this analysis at Pacific Missile Range Facility off Kauai, Hawaii indicate no changes in detection rates for several species over the past decade, demonstrating that Navy activities may not be having long-term population-level impacts. This type of analysis can be expanded to the other Navy ranges, such as the Mariana Islands Range Complex. Continued analysis of this 15-year dataset and additional monitoring efforts over time are necessary to fully understand the long-term consequences of exposure to military readiness activities.

3.4.2.1.2 Impacts from Sonar and Other Transducer Stressors

Sonar and other transducers proposed for use could be used throughout the Study Area. Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of these systems are described in Section 3.0.4.1 (Acoustic Stressors). The overall use of sonar and other transducers for training and testing activities would be similar to what is currently conducted (see Tables 2.5-1 and 2.5-2 for details). Although individual activities may vary some from those previously analyzed, the overall determinations presented in the 2015 MITT Final EIS/OEIS remain valid. The quantitative analysis has been improved upon and updated since the 2015 MITT Final EIS/OEIS; therefore, the new analysis is fully presented and described in further detail in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2018a).

Sonar-induced acoustic resonance and bubble formation phenomena are very unlikely to occur under realistic conditions, as discussed in Section 3.4.2.1.1.1 (Injury). Non-auditory injury (i.e., other than PTS) and mortality from sonar and other transducers is so unlikely as to be discountable under normal conditions and is therefore not considered further in this analysis.

The most probable impacts from exposure to sonar and other transducers are PTS, TTS, behavioral reactions, masking, and physiological stress (Section 3.4.2.1.1.2, Hearing Loss; Section 3.4.2.1.1.3, Physiological Stress; Section 3.4.2.1.1.4, Masking; and Section 3.4.2.1.1.5, Behavioral Reactions).

3.4.2.1.2.1 Methods for Analyzing Impacts from Sonar and Other Transducers

The Navy performed a quantitative analysis to estimate the number of times that marine mammals could be affected by sonars and other transducers used during Navy training and testing activities. The Navy's quantitative analysis to determine impacts on marine mammals uses the Navy Acoustic Effects Model to produce initial estimates of the number of times that animals may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of procedural mitigation measures. The steps of this quantitative analysis are described in Section 3.0.1.2 (Navy's Quantitative Analysis to Determine Impacts on Sea Turtles and Marine Mammals), which takes into account:

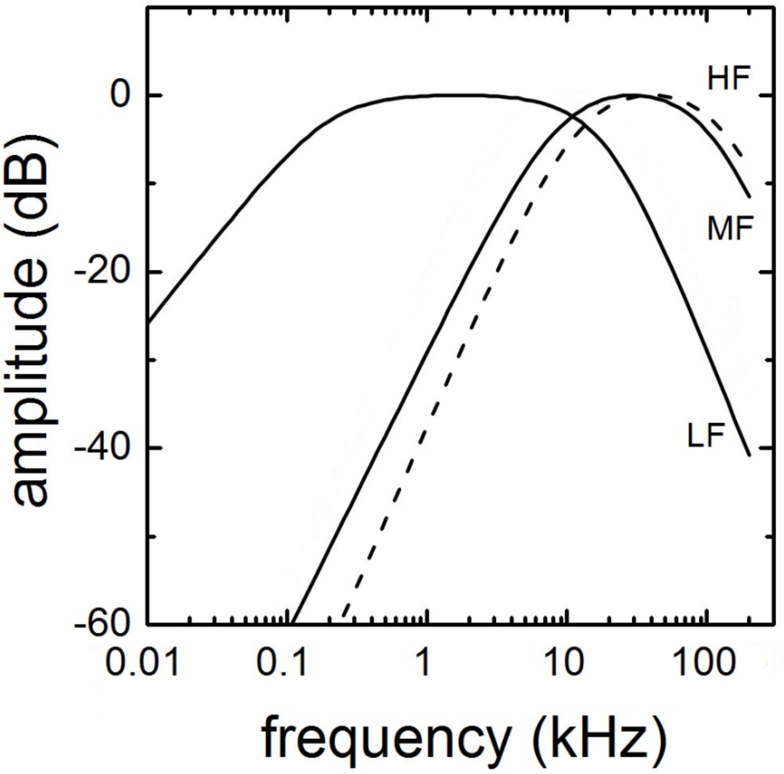
- criteria and thresholds used to predict impacts from sonar and other transducers (see below)
- the density and spatial distribution of marine mammals
- the influence of environmental parameters (e.g., temperature, depth, salinity) on sound propagation when estimating the received sound level on the animals

A detailed explanation of this analysis is provided in the technical report titled *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018a).

Criteria and Thresholds Used to Estimate Impacts from Sonar and Other Transducers

Auditory Weighting Functions

Animals are not equally sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions are used (Figure 3.4-5). Auditory weighting functions are mathematical functions that adjust received sound levels to emphasize ranges of best hearing and de-emphasize ranges with less or no auditory sensitivity. They are based on a generic band pass filter and incorporate species-specific hearing abilities to calculate a weighted received sound level in units SPL or SEL. Due to the band pass nature of auditory weighting functions, they resemble an inverted "U" shape with amplitude plotted as a function of frequency. The flatter portion of the plotted function, where the amplitude is closest to zero, is the emphasized frequency range (i.e., the pass-band), while the frequencies below and above this range (where amplitude declines) are de-emphasized.

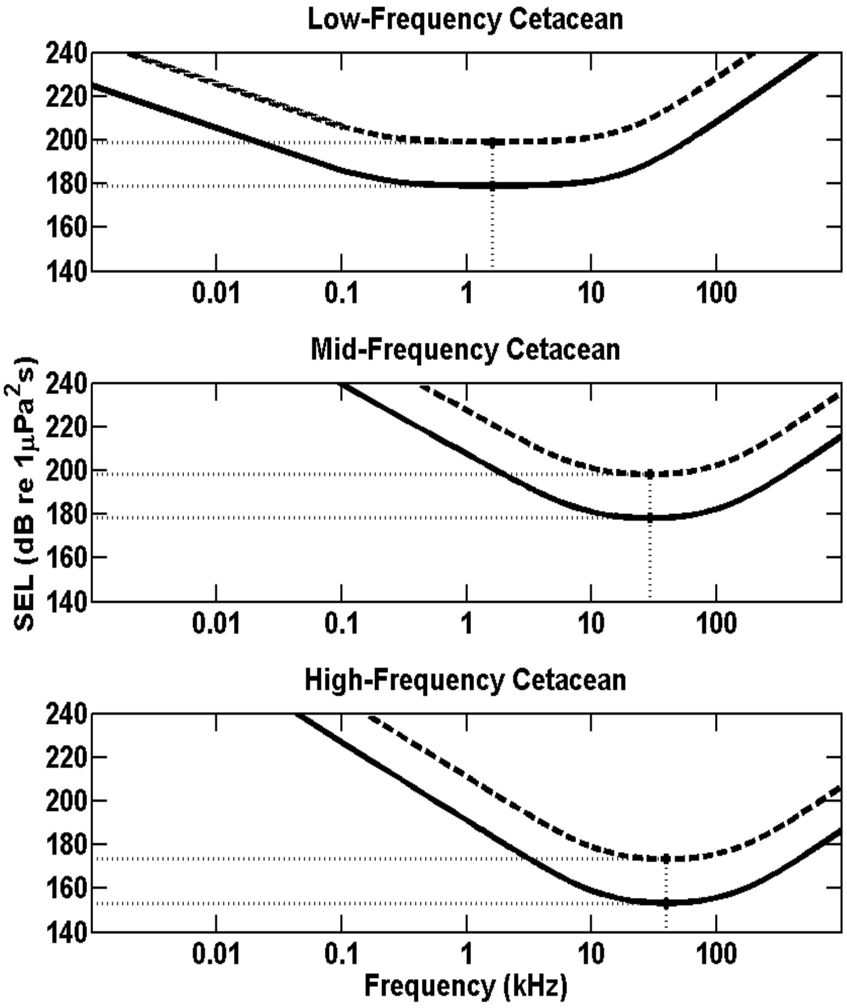


Source: For parameters used to generate the functions and more information on weighting function derivation see U.S. Department of the Navy (2017a)
Notes: HF = High-Frequency Cetacean, LF = Low-Frequency Cetacean, and MF = Mid-Frequency Cetacean

Figure 3.4-5: Navy Auditory Weighting Functions for all Species Groups

Hearing Loss from Sonar and Other Transducers

Defining the TTS and PTS exposure functions (Figure 3.4-6) requires identifying the weighted exposures necessary for TTS and PTS onset from sounds produced by sonar and other transducers. The criteria used to define threshold shifts from non-impulsive sources (e.g., sonar) determines TTS onset as the SEL necessary to induce 6 dB of threshold shift. An SEL 20 dB above the onset of TTS is used in all hearing groups of marine mammals underwater to define the PTS threshold (Southall et al., 2007).



Notes: The solid curve is the exposure function for TTS onset and the large dashed curve is the exposure function for PTS onset. Small dashed lines and asterisks indicate the SEL threshold for TTS and PTS onset in the frequency range of best hearing.

Figure 3.4-6: TTS and PTS Exposure Functions for Sonar and Other Transducers

Behavioral Responses from Sonar and Other Transducers

Behavioral response criteria are used to estimate the number of animals that may exhibit a behavioral response to sonar and other transducers. See the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* technical report for detailed information on how the Behavioral Response Functions were derived (U.S. Department of the Navy, 2017a). Developing the new behavioral criteria involved multiple steps. All peer-reviewed published behavioral response studies conducted both in the field and on captive animals were examined in order to understand the breadth of behavioral responses of marine mammals to sonar and other transducers.

The data from the behavioral studies were analyzed by looking for significant responses, or lack thereof, for each experimental session. The terms “significant response” or “significant behavioral response” are used in describing behavioral observations from field or captive animal research that may rise to the level of "harassment" for military readiness activities. Under the MMPA, for military readiness activities, such as Navy training and testing, behavioral "harassment" is: "any act that *disturbs* or is likely to *disturb* a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering*, to a point where such behavioral patterns are abandoned or significantly altered*" (16 U.S.C. section 1362(3)(18)(B)).

The likelihood of injury due to disruption of normal behaviors would depend on many factors, such as the duration of the response, from what the animal is being diverted, and the life history of the animal. Due to the nature of behavioral response research to date, it is not currently possible to ascertain the types of observed reactions that would lead to an abandonment or significant alteration of a natural behavior pattern. Therefore, the Navy has developed a methodology to estimate the possible significance of behavioral reactions and impacts on natural behavior patterns.

Behavioral response severity is described herein as "low," "moderate," or "high." These are derived from the Southall et al. (2007) severity scale. Low severity responses are those behavioral responses that fall within an animal's range of typical (baseline) behaviors and are unlikely to disrupt an individual to a point where natural behavior patterns are significantly altered or abandoned. Low severity responses include an orientation or startle response, change in respiration, change in heart rate, and change in group spacing or synchrony.

Moderate severity responses could become significant if sustained over a longer duration. What constitutes a long-duration response is different for each situation and species, although it is likely dependent upon the magnitude of the response and species characteristics such as age, body size, feeding strategy, and behavioral state at the time of the exposure. In general, a response could be considered "long-duration" if it lasted for tens of minutes to a few hours, or enough time to significantly disrupt an animal's daily routine.

Moderate severity responses included

- alter migration path,
- alter locomotion (speed, heading),
- alter dive profiles,
- stop/alter nursing,
- stop/alter breeding,
- stop/alter feeding/foraging,
- stop/alter sheltering/resting,
- stop/alter vocal behavior if tied to foraging or social cohesion, and
- avoid area near sound source.

For the derivation of behavioral criteria, a significant duration was defined as a response that lasted for the duration of exposure or longer, regardless of how long the exposure session may have been. This assumption was made because it was not possible to tell if the behavioral responses would have continued if the exposure had continued. The costs associated with these observed behavioral reactions were not measured, so it is not possible to judge whether reactions would have risen to the level of significance as defined above, although it was conservatively assumed the case. High severity responses include those responses with immediate consequences (e.g., stranding, mother-calf separation), and were always considered significant behavioral reactions regardless of duration.

Marine mammal species were placed into behavioral criteria groups based on their known or suspected behavioral sensitivities to sound (Figure 3.4-7 through Figure 3.4-9). In most cases, these divisions are driven by taxonomic classifications (e.g., mysticetes, odontocetes). The Odontocete group combines most of the mid- and high-frequency cetaceans, without the beaked whales. These groups are combined as there are not enough data to separate them for behavioral responses.

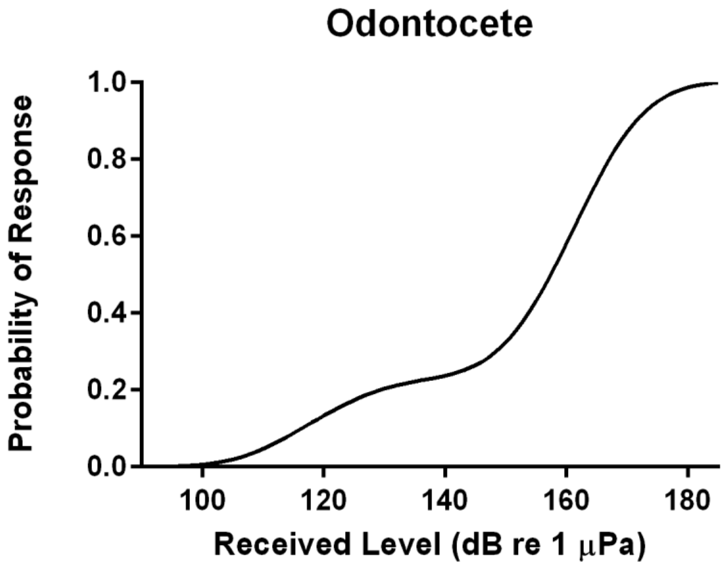


Figure 3.4-7: Behavioral Response Function for Odontocetes

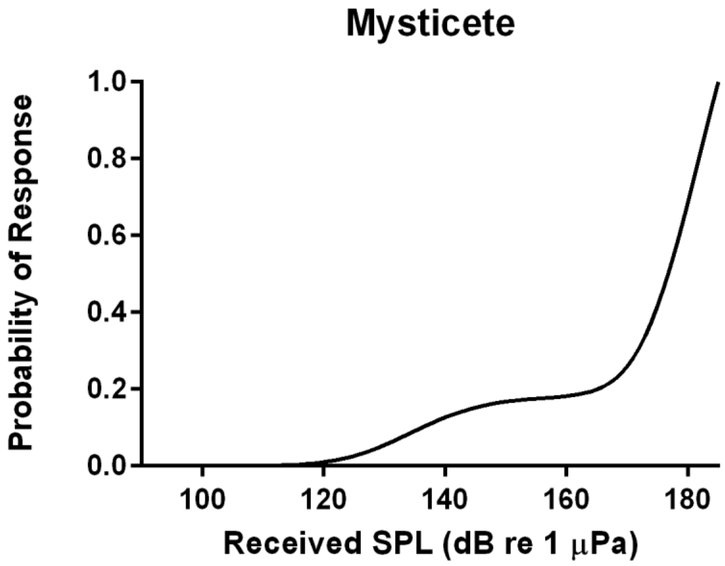


Figure 3.4-8: Behavioral Response Function for Mysticetes

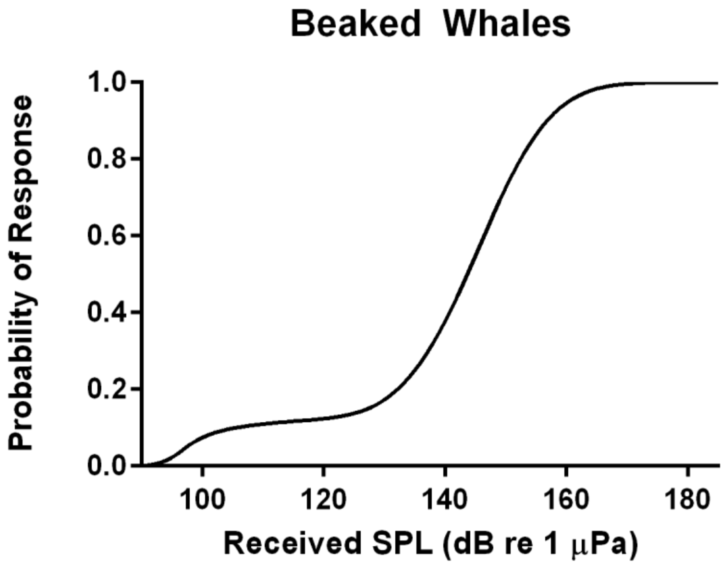


Figure 3.4-9: Behavioral Response Function for Beaked Whales

For all taxa, distances beyond which significant behavioral responses to sonar and other transducers are unlikely to occur, denoted as “cutoff distances,” were defined based on existing data (Table 3.4-3). The distance between the animal and the sound source is a strong factor in determining that animal’s potential reaction (e.g., DeRuiter et al., 2013b). For training and testing events that contain multiple platforms or tactical sonar sources that exceed 215 dB re 1 µPa at 1 m, this cutoff distance is substantially increased (i.e., doubled) from values derived from the literature. The use of multiple platforms and intense sound sources are factors that probably increase responsiveness in marine mammals overall. There are currently few behavioral observations under these circumstances; therefore, the Navy will conservatively predict significant behavioral responses at further ranges for these more intense activities.

Table 3.4-3: Cutoff Distances for Moderate Source Level, Single Platform Training and Testing Events and for All Other Events with Multiple Platforms or Sonar with Source Levels at or Exceeding 215 dB re 1 µPa at 1 m

Criteria Group	*Moderate SL/Single Platform Cutoff Distance*	*High SL/Multi-Platform Cutoff Distance*
Odontocetes	10 km	20 km
Mysticetes	10 km	20 km
Beaked Whales	25 km	50 km

Notes: km = kilometer(s), SL = source level

Assessing the Severity of Behavioral Responses from Sonar Under Military Readiness

As discussed above, the terms “significant response” or “significant behavioral response” are used in describing behavioral reactions that may lead to an abandonment or significant alteration of a natural behavior pattern. Due to the limited amount of behavioral response research to date and relatively short durations of observation, it is not possible to ascertain the true significance of the majority of the observed reactions. When deriving the behavioral criteria, it was assumed that most reactions that lasted for the duration of the sound exposure or longer were significant, even though many of the exposures lasted for 30 minutes or less. Furthermore, the experimental designs used during many of the behavioral response studies were unlike Navy activities in many important ways. These differences include tagging subject animals, following subjects for sometimes hours before the exposure, vectoring towards the subjects after animals began to avoid the sound source, and making multiple close passes on focal groups. This makes the estimated behavioral impacts from Navy activities using the criteria derived from these experiments difficult to interpret. While the state of science does not currently support definitively distinguishing between significant and insignificant behavioral reactions, as described in the technical report titled *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a), the Navy's analysis incorporates conservative assumptions to account for this uncertainty and therefore likely overestimates the potential impacts.

The estimated behavioral reactions from the Navy's quantitative analysis are grouped into several categories based on the most powerful sonar source, the number of platforms, the duration, and geographic extent of each Navy activity attributed to the predicted impact. Activities that occur on Navy instrumented ranges or within Navy homeports require special consideration due to the repeated nature of activities in these areas.

Low severity responses are within an animal's range of typical (baseline) behaviors and are unlikely to disrupt an individual to a point where natural behavior patterns are significantly altered or abandoned. Although the derivation of the Navy's behavioral criteria did not count low severity responses as significant behavioral responses, in practice, some reactions estimated using the behavioral criteria are likely to be low severity (Figure 3.4-10).

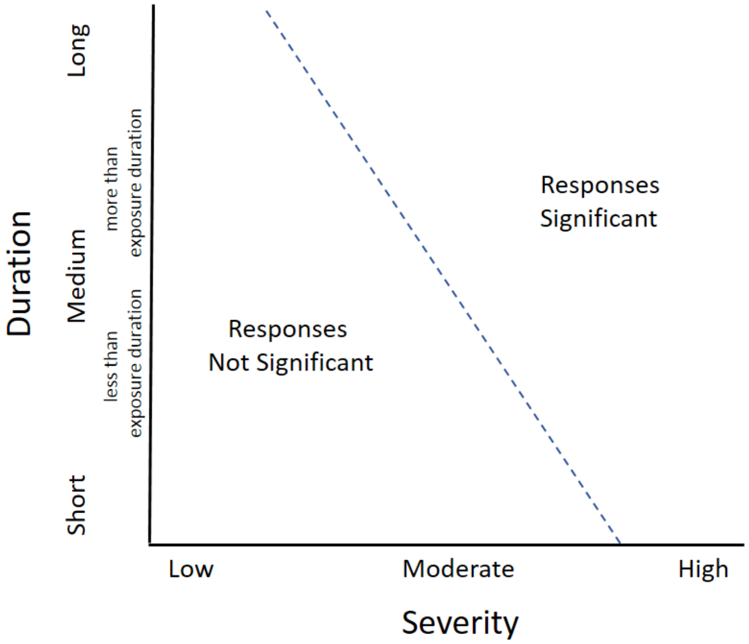


Figure 3.4-10: Relative Likelihood of a Response Being Significant Based on the Duration and Severity of Behavioral Reactions

High severity responses are those with a higher potential for direct consequences to growth, survivability, or reproduction. Examples include prolonged separation of females and dependent offspring, panic, flight, stampede, or stranding. High severity reactions would always be considered significant; however, these types of reactions are probably rare under most conditions and may still not lead to direct consequences on survivability. For example, a separation of a killer whale mother-calf pair was observed once during a behavioral response study to an active sonar source (Miller et al., 2014), but the animals were rejoined as soon as the ship had passed. Therefore, although this was a severe response, it did not lead to a negative outcome. Five beaked whale strandings have also occurred associated with U.S. Navy active sonar use as discussed above (see Section 3.4.2.1.1.6, Stranding), but the confluence of factors that contributed to those strandings is now better understood, and the avoidance of those factors has resulted in no known marine mammal strandings associated with U.S. Navy sonar activities for over a decade. The Navy is unable to predict these high severity responses for any activities since the probability of occurrence is apparently very low, although the Navy acknowledges that severe reactions could occasionally occur. In fact, no significant behavioral responses such as panic, stranding, or other severe reactions have been observed during monitoring of actual training or testing activities.

The responses estimated using the Navy's quantitative analysis are most likely to be moderate severity. Moderate severity responses would be considered significant if they were sustained for a duration long enough that it caused an animal to be outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. As mentioned previously, the behavioral response functions used within the Navy's quantitative analysis were primarily derived from experiments using short-duration sound exposures that in many cases lasted for less than 30 minutes. If animals exhibited moderate severity reactions for the duration of the exposure or longer, then it was conservatively assumed that the animal experienced a significant behavioral reaction. However, the experiments did not include measurements of costs to animals beyond the immediately observed reactions, and no direct correlations exist between an observed behavioral response and a cost that may result in long-term consequences. Within the Navy's quantitative analysis, many behavioral reactions are estimated from exposure to sonar that may exceed an animal's behavioral threshold for only a single ping to several minutes. While the state of science does not currently support definitively distinguishing between significant and insignificant behavioral reactions, as described in the technical report titled *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a), the Navy's analysis incorporates conservative assumptions to account for this uncertainty and therefore likely overestimates the potential impacts.

Accounting for Mitigation

The Navy will implement mitigation measures to avoid or reduce potential impacts from active sonar on marine mammals, as described in Section 5.3.2.1 (Active Sonar). The benefits of mitigation are conservatively factored into the analysis for Alternative 1 and Alternative 2 of the Proposed Action for training and testing. The Navy's mitigation measures are identical for both action alternatives.

Procedural mitigation measures include a power down or shut down (i.e., power off) of applicable active sonar sources when a marine mammal is observed in a mitigation zone. The mitigation zones for active sonar activities were designed to avoid the potential for marine mammals to be exposed to levels of sound that could result in auditory injury (i.e., PTS) from active sonar to the maximum extent practicable. The mitigation zones for active sonar extend beyond the respective average ranges to auditory injury (including PTS). Therefore, the impact analysis quantifies the potential for procedural mitigation to reduce the risk of PTS. Two factors are considered when quantifying the effectiveness of procedural mitigation: (1) 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; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018a).

In the quantitative analysis, consideration of mitigation measures means that, for activities that implement mitigation, some model-estimated PTS is considered mitigated to the level of TTS. The impact analysis does not analyze the potential for mitigation to reduce TTS or behavioral effects, even though mitigation could also reduce the likelihood of these effects. In practice, mitigation also protects all unobserved (below the surface) animals in the vicinity, including other species, in addition to the observed animal. However, the analysis assumes that only animals sighted at the water surface would be protected by the applied mitigation. The analysis, therefore, does not capture the protection afforded to all marine species that may be near or within the mitigation zone.

The ability to observe the ranges to PTS was estimated for each training or testing event. The ability of Navy Lookouts to detect marine mammals within a mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as group size or surface active behavior). The behaviors and characteristics of some species may make them easier to detect. Certain behaviors, such as leaping and breaching, are visible from a great distance and likely increase sighting distances and detections of those species. Environmental conditions under which the training or testing activity could take place are also considered, such as sea surface conditions, weather (e.g., fog or rain), and day versus night.

The Navy will also implement mitigation measures for certain active sonar activities within mitigation areas, as described in Appendix I (Geographic Mitigation Assessment). The benefits of mitigation areas are discussed qualitatively and have not been factored into the quantitative analysis process or reductions in take for the MMPA and ESA impact estimates. Mitigation areas are designed to help avoid or reduce impacts during biologically important life processes within particularly important habitat areas. Therefore, mitigation area benefits are discussed in terms of the context of impact avoidance or reduction.

Marine Mammal Avoidance of Sonar and other Transducers

Because a marine mammal is assumed to initiate avoidance behavior after an initial startle reaction when exposed to relatively high received levels of sound, a marine mammal could reduce its cumulative sound energy exposure over a sonar event with multiple pings (i.e., sound exposures). This would reduce risk of both PTS and TTS, although the quantitative analysis conservatively only considers the potential to reduce instances of PTS by accounting for marine mammals swimming away to avoid repeated high-level sound exposures. All reductions in PTS impacts from likely avoidance behaviors are instead considered TTS impacts.

3.4.2.1.2.2 Impact Ranges for Sonar and Other Transducers

The following section provides range to effects for sonar and other transducers to specific criteria determined using the Navy Acoustic Effects Model. Marine mammals within these ranges would be predicted to receive the associated effect. Range to effects is important information in not only predicting acoustic impacts, but also in verifying the accuracy of model results against real-world situations and assessing the level of impact that will likely be mitigated within applicable mitigation zones.

The ranges to the PTS threshold for an exposure of 30 seconds are shown in Table 3.4-4 relative to the marine mammal's functional hearing group. This period (30 seconds) was chosen based on examining the maximum amount of time a marine mammal would realistically be exposed to levels that could cause the onset of PTS based on platform (e.g., ship) speed and a nominal animal swim speed of approximately 1.5 meters per second. The ranges provided in the table include the average range to PTS, as well as the range from the minimum to the maximum distance at which PTS is possible for each hearing group. Since any hull-mounted sonar, such as the SQS-53, engaged in anti-submarine warfare training would be moving at between 10 and 15 knots and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 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). For all other bins (besides MF1), PTS ranges are short enough that marine mammals (with a nominal swim speed of approximately 1.5 meters per second) should be able to avoid higher sound levels capable of causing onset PTS within this 30-second period.

For all other functional hearing groups (low-frequency cetaceans and mid-frequency cetaceans), 30-second average PTS zones are substantially shorter. A scenario could occur where an animal does not leave the vicinity of a ship or travels a course parallel to the ship, however, the close distances required make PTS exposure unlikely. For a Navy 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 suffer PTS.

The tables below illustrate the range to TTS for 1, 30, 60, and 120 seconds from five representative sonar systems (see Table 3.4-5 through Table 3.4-9). Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer. Therefore, successive pings can be expected to add together, further increasing the range to onset-TTS.

Table 3.4-4: Range to Permanent Threshold Shift for Five Representative Sonar Systems

Hearing Group	***Approximate PTS (30 seconds) Ranges (meters)[1]***				
	Sonar bin HF4	***Sonar bin LF4***	***Sonar bin MF1***	***Sonar bin MF4***	***Sonar bin MF5***
High-frequency cetaceans	29 (22–35)	0 (0–0)	181 (180–190)	30 (30–30)	9 (8–10)
Low-frequency cetaceans	0 (0–0)	0 (0–0)	65 (65–65)	15 (15–15)	0 (0–0)
Mid-frequency cetaceans	1 (0–1)	0 (0–0)	16 (16–16)	3 (3–3)	0 (0–0)

[1] PTS ranges extend from the sonar or other transducers to the indicated distance. The average range to PTS is provided as well as the range from the estimated minimum to the maximum range to PTS in parentheses.

Notes: HF= high-frequency, LF = low-frequency, MF = mid-frequency, PTS = permanent threshold shift

Table 3.4-5: Ranges to Temporary Threshold Shift for Sonar Bin HF4 over a Representative Range of Environments within the Study Area

Hearing Group	***Approximate TTS Ranges (meters)[1]***			
	Sonar Bin HF4			
	1 second	***30 seconds***	***60 seconds***	***120 seconds***
High-frequency cetaceans	155 (110–210)	259 (180–350)	344 (240–480)	445 (300–600)
Low-frequency cetaceans	1 (0–2)	2 (1–3)	4 (3–5)	7 (5–8)
Mid-frequency cetaceans	10 (7–12)	17 (12–21)	24 (17–30)	33 (25–40)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.

Notes: HF = high-frequency, TTS = temporary threshold shift

Table 3.4-6: Ranges to Temporary Threshold Shift for Sonar Bin LF4 over a Representative Range of Environments within the Study Area

Hearing Group	***Approximate TTS Ranges (meters)[1]***			
	Sonar Bin LF4			
	1 second	***30 seconds***	***60 seconds***	***120 seconds***
High-frequency cetaceans	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Low-frequency cetaceans	3 (3–3)	4 (4–4)	6 (6–6)	9 (9–9)
Mid-frequency cetaceans	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.

Notes: LF = low-frequency, TTS = temporary threshold shift

Table 3.4-7: Ranges to Temporary Threshold Shift for Sonar Bin MF1 over a Representative Range of Environments within the Study Area

Hearing Group	***Approximate TTS Ranges (meters)[1]***			
	Sonar Bin MF1			
	1 second	***30 seconds***	***60 seconds***	***120 seconds***
High-frequency cetaceans	3,181 (2,025–5,025)	3,181 (2,025–5,025)	5,298 (2,275–7,775)	6,436 (2,525–9,775)
Low-frequency cetaceans	898 (850–1,025)	898 (850–1,025)	1,271 (1,025–1,525)	1,867 (1,275–3,025)
Mid-frequency cetaceans	210 (200–210)	210 (200–210)	302 (300–310)	377 (370–390)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.
Notes: Ranges for 1-sec and 30-sec periods are identical for Bin MF1 because this system nominally pings every 50 seconds; therefore, these periods encompass only a single ping.
Notes: MF = mid-frequency, TTS = temporary threshold shift

Table 3.4-8: Ranges to Temporary Threshold Shift for Sonar Bin MF4 over a Representative Range of Environments within the Study Area

Hearing Group	***Approximate TTS Ranges (meters)[1]***			
	Sonar Bin MF4			
	1 second	***30 seconds***	***60 seconds***	***120 seconds***
High-frequency cetaceans	232 (220–260)	454 (420–600)	601 (575–875)	878 (800–1,525)
Low-frequency cetaceans	85 (85–90)	161 (160–170)	229 (220–250)	352 (330–410)
Mid-frequency cetaceans	22 (22–22)	35 (35–35)	50 (45–50)	70 (70–70)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.
Notes: MF = mid-frequency, TTS = temporary threshold shift

Table 3.4-9: Ranges to Temporary Threshold Shift for Sonar Bin MF5 over a Representative Range of Environments within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)[1]*			
	Sonar Bin MF5			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	114 (110–130)	114 (110–130)	168 (150–200)	249 (210–290)
Low-frequency cetaceans	11 (10–12)	11 (10–12)	16 (16–17)	23 (23–24)
Mid-frequency cetaceans	5 (0–9)	5 (0–9)	12 (11–13)	18 (17–18)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.
Notes: MF = mid-frequency, TTS = temporary threshold shift

The range to received sound levels in 6-dB steps from five representative sonar bins and the percentage of animals that may exhibit a significant behavioral response under each behavioral response function are shown in Table 3.4-10 through Table 3.4-14, respectively. See Section 3.4.2.1.2.1 (Methods for Analyzing Impacts from Sonar and Other Transducers) for details on the derivation and use of the behavioral response functions, thresholds, and the cutoff distances.

Table 3.4-10: Ranges to a Potentially Significant Behavioral Response for Sonar Bin HF4 over a Representative Range of Environments within the Study Area

Received Level (dB re 1 µPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin HF4*		
		Odontocete	*Mysticete*	*Beaked Whale*
196	3 (2–4)	100%	100%	100%
190	8 (6–10)	100%	98%	100%
184	16 (12–20)	99%	88%	100%
178	32 (24–40)	97%	59%	100%
172	63 (45–80)	91%	30%	99%
166	120 (75–160)	78%	20%	97%
160	225 (120–310)	58%	18%	93%
154	392 (180–550)	40%	17%	83%
148	642 (280–1,275)	29%	16%	66%
142	916 (420–1,775)	25%	13%	45%
136	1,359 (625–2,525)	23%	9%	28%
130	1,821 (950–3,275)	20%	5%	18%
124	2,567 (1,275–5,025)	17%	2%	14%
118	3,457 (1,775–6,025)	12%	1%	12%
112	4,269 (2,275–7,025)	6%	0%	11%
106	5,300 (3,025–8,025)	3%	0%	11%
100	6,254 (3,775–9,275)	1%	0%	8%

Notes: dB re 1 µPa = decibels referenced to 1 micropascal, HF = high-frequency

Table 3.4-11: Ranges to a Potentially Significant Behavioral Response for Sonar Bin LF4 over a Representative Range of Environments within the Study Area

Received Level (dB re 1 µPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin LF4*		
		Odontocete	*Mysticete*	*Beaked Whale*
196	1 (1–1)	100%	100%	100%
190	3 (3–3)	100%	98%	100%
184	6 (6–6)	99%	88%	100%
178	12 (12–12)	97%	59%	100%
172	25 (25–25)	91%	30%	99%
166	51 (50–55)	78%	20%	97%
160	130 (130–160)	58%	18%	93%
154	272 (270–300)	40%	17%	83%
148	560 (550–675)	29%	16%	66%
142	1,048 (1,025–1,525)	25%	13%	45%
136	2,213 (1,525–4,525)	23%	9%	28%
130	4,550 (2,275–24,025)	20%	5%	18%
124	16,903 (4,025–66,275)	17%	2%	14%
118	43,256 (7,025–87,775)	12%	1%	12%
112	60,155 (7,775–100,000*)	6%	0%	11%
106	80,689 (8,775–100,000*)	3%	0%	11%
100	92,352 (9,025–100,000*)	1%	0%	8%

* Indicates maximum range to which acoustic model was run, a distance of approximately 100 km from the sound source.

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 3.4-3 for behavioral cut-off distances).

dB re 1 µPa = decibels referenced to 1 micropascal, LF = low-frequency

Table 3.4-12: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF1 over a Representative Range of Environments within the Study Area

Received Level (dB re 1 µPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin MF1*		
		Odontocete	*Mysticete*	*Beaked Whale*
196	106 (100–110)	100%	100%	100%
190	240 (240–250)	100%	98%	100%
184	501 (490–525)	99%	88%	100%
178	1,019 (975–1,025)	97%	59%	100%
172	3,275 (2,025–5,275)	91%	30%	99%
166	7,506 (2,525–11,025)	78%	20%	97%
160	15,261 (4,775–20,775)	58%	18%	93%
154	27,759 (5,525–36,525)	40%	17%	83%
148	43,166 (7,525–65,275)	29%	16%	66%
142	58,781 (8,525–73,525)	25%	13%	45%
136	71,561 (11,275–90,775)	23%	9%	28%
130	83,711 (13,025–100,000*)	20%	5%	18%
124	88,500 (23,525–100,000*)	17%	2%	14%
118	90,601 (27,025–100,000*)	12%	1%	12%
112	92,750 (27,025–100,000*)	6%	0%	11%
106	94,469 (27,025–100,000*)	3%	0%	11%
100	95,838 (27,025–100,000*)	1%	0%	8%

* Indicates maximum range to which acoustic model was run, a distance of approximately 100 km from the sound source.

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 3.4-3 for behavioral cut-off distances).

dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

Table 3.4-13: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF4 over a Representative Range of Environments within the Study Area

Received Level (dB re 1 µPa)	***Mean Range (meters) with Minimum and Maximum Values in Parentheses***	***Probability of Behavioral Response for Sonar Bin MF4***		
		Odontocete	***Mysticete***	***Beaked Whale***
196	8 (8–8)	100%	100%	100%
190	17 (17–17)	100%	98%	100%
184	35 (35–35)	99%	88%	100%
178	70 (65–70)	97%	59%	100%
172	141 (140–150)	91%	30%	99%
166	354 (330–420)	78%	20%	97%
160	773 (725–1,275)	58%	18%	93%
154	1,489 (1,025–3,275)	40%	17%	83%
148	3,106 (1,775–6,775)	29%	16%	66%
142	8,982 (3,025–18,775)	25%	13%	45%
136	15,659 (3,775–31,025)	23%	9%	28%
130	25,228 (4,775–65,775)	20%	5%	18%
124	41,778 (5,525–73,275)	17%	2%	14%
118	51,832 (6,025–89,775)	12%	1%	12%
112	62,390 (6,025–100,000*)	6%	0%	11%
106	69,235 (6,775–100,000*)	3%	0%	11%
100	73,656 (7,025–100,000*)	1%	0%	8%

* Indicates maximum range to which acoustic model was run, a distance of approximately 100 km from the sound source.

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 3.4-3 for behavioral cut-off distances).

dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

Table 3.4-14: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF5 over a Representative Range of Environments within the Study Area

Received Level (dB re 1 µPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin MF5*		
		Odontocete	*Mysticete*	*Beaked Whale*
196	0 (0–0)	100%	100%	100%
190	1 (0–3)	100%	98%	100%
184	4 (0–7)	99%	88%	100%
178	14 (0–15)	97%	59%	100%
172	29 (0–30)	91%	30%	99%
166	58 (0–60)	78%	20%	97%
160	125 (0–150)	58%	18%	93%
154	284 (160–525)	40%	17%	83%
148	607 (450–1,025)	29%	16%	66%
142	1,213 (875–4,025)	25%	13%	45%
136	2,695 (1,275–7,025)	23%	9%	28%
130	6,301 (2,025–12,525)	20%	5%	18%
124	10,145 (3,025–19,525)	17%	2%	14%
118	14,359 (3,525–27,025)	12%	1%	12%
112	19,194 (3,525–37,275)	6%	0%	11%
106	24,153 (4,025–48,025)	3%	0%	11%
100	29,325 (5,025–57,775)	1%	0%	8%

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 3.4-3 for behavioral cut-off distances).
dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

3.4.2.1.2.3 Impacts from Sonar and Other Transducers Under the Action Alternatives

Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. Use of sonar and other transducers would typically be transient and temporary. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training and testing under Alternative 1 and 2 are described in Section 3.0.4.1 (Acoustic Stressors). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Training and Testing Activities Descriptions). The major differences between the action alternatives for the purposes of analyzing impacts on marine mammals are:

- Under Alternative 1, training and testing activities would fluctuate each year to account for the natural variation of training cycles and deployment schedules.

- Under Alternative 2, the same type and tempo of military training and testing activities would occur as Alternative 1, but there would be five Joint Multi-Strike Group Exercises (e.g., Valiant Shield) over any five-year period as compared to three under Alternative 1. Additionally, Alternative 2 contemplates three (vice two) Small Joint Coordinated ASW exercises (Multi-Sail/GUAMEX) per year with a 50 percent increase in associated unit-level events (e.g., Missile

Exercise (Surface-to-Air). This would result in an increase of active sonar training compared to Alternative 1. There would also be an increase in the use of active sonar during certain testing events. Alternative 2 reflects the maximum number of training and testing activities that could occur within a given year, and assumes that the maximum number of Fleet exercises would occur every year.

Compared to training and testing activities that use sonar and other transducers that were previously analyzed in the 2015 MITT Final EIS/OEIS under Alternatives 1 and 2, some training and testing activities would increase, decrease, or stay the same from those currently conducted (see Table 2.5-1 and Table 2.5-2 for details). In addition, some new systems using new technologies will be tested under the action alternatives.

Major training exercises are multi-day exercises that transition across large areas and involve multiple anti-submarine warfare assets. It is important to note that, while major training exercises focus on anti-submarine warfare, there are significant periods when active anti-submarine warfare sonars are not in use. Nevertheless, behavioral reactions are assumed more likely to be significant than during other anti-submarine warfare activities due to the duration (i.e., multiple days) and scale (i.e., multiple sonar platforms) of the major training exercises. Although major training exercises tend to move to different locations as the event unfolds, some animals could be exposed multiple times over the course of a few days.

Anti-submarine warfare activities also include unit-level training and coordinated/integrated training, and anti-submarine warfare sonar systems would be active when conducting surface ship and submarine sonar maintenance. Submarine and surface ship sonar maintenance activities involve the use of a single system in a limited manner; therefore, significant reactions to maintenance are less likely than with most other anti-submarine warfare activities. Furthermore, sonar maintenance activities typically occur either pierside or within entrances to harbors where higher levels of anthropogenic activity, including elevated noise levels, already exist. Unit-level training activities typically involve the use of a single vessel or aircraft and last for only a few hours over a small area of ocean. These unit-level training and sonar maintenance activities are limited in scope and duration; therefore, significant behavioral reactions are less likely than with other anti-submarine warfare activities with greater intensity and duration. Unit-level training activities are more likely to occur close to homeports and in the same general locations each time, so resident animals could be more frequently exposed to these types of activities. Coordinated/integrated exercises involve multiple assets and can last for several days transiting across large areas of a range complex. Repeated exposures to some individual marine mammals are likely during coordinated/integrated exercises. However, due to the shorter duration and smaller footprint compared to major training exercises, impacts from these activities are less likely to be significant with the possible exception of resident animals near homeports or Navy instrumented ranges that may incur some repeated exposures.

Anti-submarine warfare testing activities are typically similar to unit-level training. Vessel evaluation testing activities also use the same anti-submarine warfare sonars on ships and submarines. Testing activities that use anti-submarine warfare sonars typically occur in water deeper than approximately 200 m and therefore out of most nearshore habitats where productivity is typically higher (i.e., more food) and many marine mammals have higher abundances. Therefore, significant reactions to anti-submarine warfare and vessel evaluation testing activities are less likely than with larger anti-submarine warfare training activities discussed. Anti-submarine warfare and vessel evaluation testing activities are more likely to occur close to homeports and testing facilities and in the same general locations each time, so resident animals could be more frequently exposed to these types of activities. These testing activities are limited in scope and duration; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Mine warfare training activities typically involve a ship, helicopter, or unmanned vehicle using a mine-hunting sonar to locate mines. Most mine warfare sonar systems have a lower source level, higher frequency, and narrower, often downward facing beam pattern as compared to most anti-submarine warfare sonars. Significant reactions in marine mammals have not been reported due to exposure to mine warfare sonars. While individual animals could show short-term and minor responses to mine warfare sonar training activities, these reactions are very unlikely to lead to any costs or long-term consequences for individuals or populations.

Mine warfare testing activities typically involve a ship, helicopter, or unmanned vehicle testing a mine-hunting sonar system. Unmanned underwater vehicle testing also employs many of the same sonar systems as mine warfare testing and usually involves only a single sonar platform (i.e., unmanned underwater vehicle). Most of the sonar systems and other transducers used during these testing activities typically have a lower source level, higher frequency, and narrower, often downward facing beam pattern as compared to most anti-submarine warfare sonars. Significant reactions in marine mammals have not been reported due to exposure to these types of systems sonars. Animals are most likely to show short-term and minor to moderate responses to these testing activities; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Navigation and object detection activities typically employ ship and submarine-based sonar systems and other transducers to navigate and avoid underwater objects. Significant reactions in marine mammals have not been reported due to exposure to most of the sonars and other transducers typically used in these activities. Some hull-mounted anti-submarine warfare sonars (e.g., bin MF1) have a mode to look for objects in the water such as mines, but this mode uses different source characteristics as compared to the anti-submarine warfare mode. Significant behavioral reactions have not been observed in relation to hull-mounted sonars using object-detection mode; however, significant reactions may be more likely than for all other sonar systems and transducers used within these activities due to the additional presence of a moving vessel and higher source levels. Individual animals could show short-term and minor to moderate responses to these systems, although these reactions are very unlikely to lead to any costs or long-term consequences for individuals or populations.

Other testing activities include testing of individual sonar systems and other transducers for performance and acoustic signature. Most sources used during these exercises have moderate source levels between 160 and 200 dB re 1 µPa @ 1m and are used for a limited duration, up to a few hours in most cases. Significant reactions in marine mammals have not been reported due to exposure to the sonars and other transducers typically used in these activities. Animals are most likely to show short-term and minor to moderate responses to these testing activities; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Surface warfare activities require limited use of sonar or other transducers as compared to other types of activities discussed above, typically limited to the sonar targeting system of a few torpedoes. The limited scope and duration of sonar use in these activities makes significant behavioral reactions less likely than with other activities that use anti-submarine warfare sonar systems and other transducers, which are discussed above.

Presentation of Estimated Impacts from the Quantitative Analysis

The results of the analysis of potential impacts on marine mammals from sonars and other transducers (Section 3.4.2.1.2.1, Methods for Analyzing Impacts from Sonar and Other Transducers) are discussed below. The numbers of potential impacts estimated for individual species and stocks of marine mammals from exposure to sonar for training and testing activities under each action alternative are shown in Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) and presented below in figures for each species of marine mammal with any estimated effects (e.g., Figure 3.4-11). The activity categories that are most likely to cause impacts and the most likely region in which impacts could occur are represented in the impact graphics for each species. There is a potential for impacts to occur anywhere within the Study Area where sound from sonar and the species overlap, although only regions or activity categories where 0.5 percent of the impacts or greater are estimated to occur are graphically represented below. All (i.e., grand total) estimated impacts for that species are included, regardless of region or category.

It is important to note when examining the results of the quantitative analysis that the behavioral response functions used to predict the numbers of reactions in this analysis are largely derived from several studies (see Section 3.4.2.1.1.5, Behavioral Reactions). The best available science, including behavioral response studies, was used for deriving these criteria; however, many of the factors inherent in these studies that potentially increased the likelihood and severity of observed responses (e.g., close approaches by multiple vessels, tagging animals, and vectoring towards animals that have already begun avoiding the sound source) would not occur during Navy activities. Because the Navy purposely avoids approaching marine mammals, many of the behavioral responses estimated by the quantitative analysis are unlikely to occur or unlikely to rise to the severity observed during many of the behavioral response studies.

Although the statutory definition of Level B harassment for military readiness activities under the MMPA requires that the natural behavior patterns of a marine mammal be significantly altered or abandoned, the current state of science for determining those thresholds is somewhat unsettled. Therefore, in its analysis of impacts associated with acoustic sources, the Navy is adopting a conservative approach that overestimates the number of takes by Level B harassment. The responses estimated using the Navy's quantitative analysis are most likely to be moderate severity. Moderate severity responses would be considered significant if they were sustained for a duration long enough that it caused an animal to be outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. As discussed in Section 3.4.2.1.2.1 (Methods for Analyzing Impacts from Sonar and Other Transducers), the behavioral response functions used within the Navy's quantitative analysis were primarily derived from experiments using short-duration sound exposures lasting, in many cases, for less than 30 minutes. If animals exhibited moderate severity reactions for the duration of the exposure or longer, then it was conservatively assumed that the animal experienced a significant behavioral reaction. However, the experiments did not include measurements of costs to animals beyond the immediately observed reactions, and no direct correlations exist between an observed behavioral response and a cost that may result in long-term consequences. Within the Navy's quantitative analysis, many behavioral reactions are estimated from exposure to sound that may exceed an animal's behavioral threshold for only a single exposure to several minutes. It is likely that many of the estimated behavioral reactions within the Navy's quantitative analysis would not constitute significant behavioral reactions; however, the numbers of significant verses non-significant behavioral reactions are currently impossible to predict. Consequently, there is a high likelihood that significant numbers of marine mammals exposed to acoustic sources are not significantly altering or abandoning their natural behavior patterns. As such, the overall impact of acoustic sources from military readiness activities on marine mammal species and stocks is negligible (i.e., cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stocks through effects on annual rates of recruitment or survival).

Mysticetes

Mysticetes may be exposed to sound from sonar and other transducers associated with training and testing activities. Most low- (less than 1 kHz) and mid- (1–10 kHz) frequency sonars and other transducers produce sounds that are likely to be within the hearing range of mysticetes (Section 3.4.1.6, Hearing and Vocalization). Some high-frequency sonars (greater than 10 kHz) also produce sounds that should be audible to mysticetes, although only smaller species of mysticetes such as minke whales are likely to be able to hear higher frequencies, presumably up to 30 kHz. Therefore, some high-frequency sonars and other transducers with frequency ranges between 10 and 30 kHz may also be audible to some mysticetes. If a sound is within an animal's hearing range then behavioral reactions, physiological stress, masking and hearing loss are potential impacts that must be analyzed. If a marine mammal cannot hear a sound, then behavioral reactions, physiological stress, masking, or hearing loss is not likely to occur. Impact ranges for mysticetes are discussed under low-frequency cetaceans in Section 3.4.2.1.2 (Impacts from Sonar and Other Transducer Stressors).

A few behavioral reactions in mysticetes resulting from exposure to sonar could take place at distances of up to 20 km. Behavioral reactions, however, are much more likely within a few kilometers of the sound source. As discussed above in *Assessing the Severity of Behavioral Responses from Sonar and other Transducers*, the quantitative analysis very likely overestimated the numbers of behavioral reactions due to the underlying nature of the data used to derive the behavioral response functions. Research shows that if mysticetes do respond 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). Behavioral reactions may include alerting, breaking off feeding dives and surfacing, or diving or swimming away. Overall, mysticetes have been observed to be more reactive to acoustic disturbance when a noise sources is located directly on their migration route. Mysticetes disturbed while migrating could pause their migration or route around the disturbance. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Therefore, behavioral reactions from mysticetes are likely to be short-term and low to moderate severity.

Some mysticetes may avoid larger activities such as a major training exercise as it moves through an area. Vessels and aircraft associated with training or testing activities are typically in transit during an event (they are not stationary) and activities typically do not use the same training locations day after day during multi-day activities. If an event otherwise focuses on a fixed location, mysticetes may avoid the location of the activity for the duration of the event. If animals are displaced, they would likely return quickly after the event subsides. It is unlikely that most mysticetes would encounter a major training exercise more than once per year. In the ocean, the use of sonar and other transducers is transient and is unlikely to expose the same population of animals repeatedly over a short period except around homeports and fixed instrumented ranges. Overall, a few behavioral reactions per year by a single individual are unlikely to produce long-term consequences for that individual.

Behavioral research indicates that mysticetes most likely avoid sound sources at levels that would cause any hearing loss (i.e., TTS) (Section 3.4.2.1.1.5, Behavioral Reactions). Therefore, it is likely that the quantitative analysis overestimates TTS in marine mammals because it does not account for animals avoiding sound sources at closer ranges. Mysticetes that do experience PTS or TTS from sonar sounds may have reduced ability to detect biologically important sounds around the frequency band of the sonar until their hearing recovers. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. TTS would be recoverable and PTS would leave some residual hearing loss. Most TTS, if it does actually occur, would be more likely to be minor to moderate (i.e., less than 20 dB of TTS directly after the exposure) and would recover within a matter of minutes to hours (Section 3.4.2.1.1.2, Hearing Loss). Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. During the period that a mysticete had hearing loss, social calls from conspecifics could be more difficult to detect or interpret if they fell in the octave band of the sonar frequency. Killer whales are a primary predator of mysticetes. Some hearing loss could make killer whale calls more difficult to detect at farther ranges until hearing recovers. It is unclear how or if mysticetes use sound for finding prey or feeding; therefore, it is unknown whether hearing loss would affect a mysticete's ability to locate prey or rate of feeding. A single or even a few minor TTS (less than 20 dB of TTS) to an individual mysticete per year are unlikely to have any long-term consequences for that individual.

Research and observations of masking in marine mammals are discussed in Section 3.4.2.1.1.4 (Masking). Most anti-submarine warfare sonars and countermeasures use mid-frequency ranges and a few use low-frequency ranges. Most of these sonar signals are limited in the temporal, frequency, and spatial domains. The duration of most individual sounds is short, lasting up to a few seconds each. Some systems operate with higher duty cycles or nearly continuously, but typically use lower power. Nevertheless, masking may be more prevalent at closer ranges to these high-duty cycle and continuous active sonar systems. Most anti-submarine warfare activities are geographically dispersed and last for only a few hours, often with intermittent sonar use even within this period. Most anti-submarine warfare sonars also have a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood of sources causing significant masking in mysticetes. High-frequency sonars are typically used for mine hunting, navigation, and object detection (avoidance). High-frequency (greater than 10 kHz) sonars fall outside of the best hearing and vocalization ranges of mysticetes (see Section 3.4.1.6, Hearing and Vocalization). Furthermore, high frequencies (above 10 kHz) attenuate more rapidly in the water due to absorption than do lower frequency signals, thus producing only a small zone of potential masking. Masking in mysticetes due to exposure to high-frequency sonar is unlikely. Potential costs to mysticetes from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively pinging and the effect is over the moment the sound has ceased. By contrast, hearing loss lasts beyond the exposure for a period. Nevertheless, mysticetes that do experience some masking for a short period from low- or mid-frequency sonar may have their ability to communicate with conspecifics reduced, especially at further ranges. However, larger mysticetes (e.g., blue whale, fin whale, sei whale) communicate at frequencies below those of mid-frequency sonar and even most low-frequency sonars. Mysticetes that communicate at higher frequencies (e.g., minke whale) may be affected by some short-term and intermittent masking. Sounds from mid-frequency sonar could mask killer whale vocalizations making them more difficult to detect, especially at further ranges. It is unknown whether masking would affect a mysticete's ability to feed since it is unclear how or if mysticetes use sound for finding prey or feeding. A single or even a few short periods of masking, if it were to occur, to an individual mysticete per year are unlikely to have any long-term consequences for that individual.

Many activities such as submarine under ice certification and most mine hunting exercises use only high-frequency sonars that are not within mysticetes' hearing range; therefore, there were no predicted effects. Section 3.4.1.6 (Hearing and Vocalization) discusses low-frequency cetacean (i.e., mysticetes) hearing abilities.

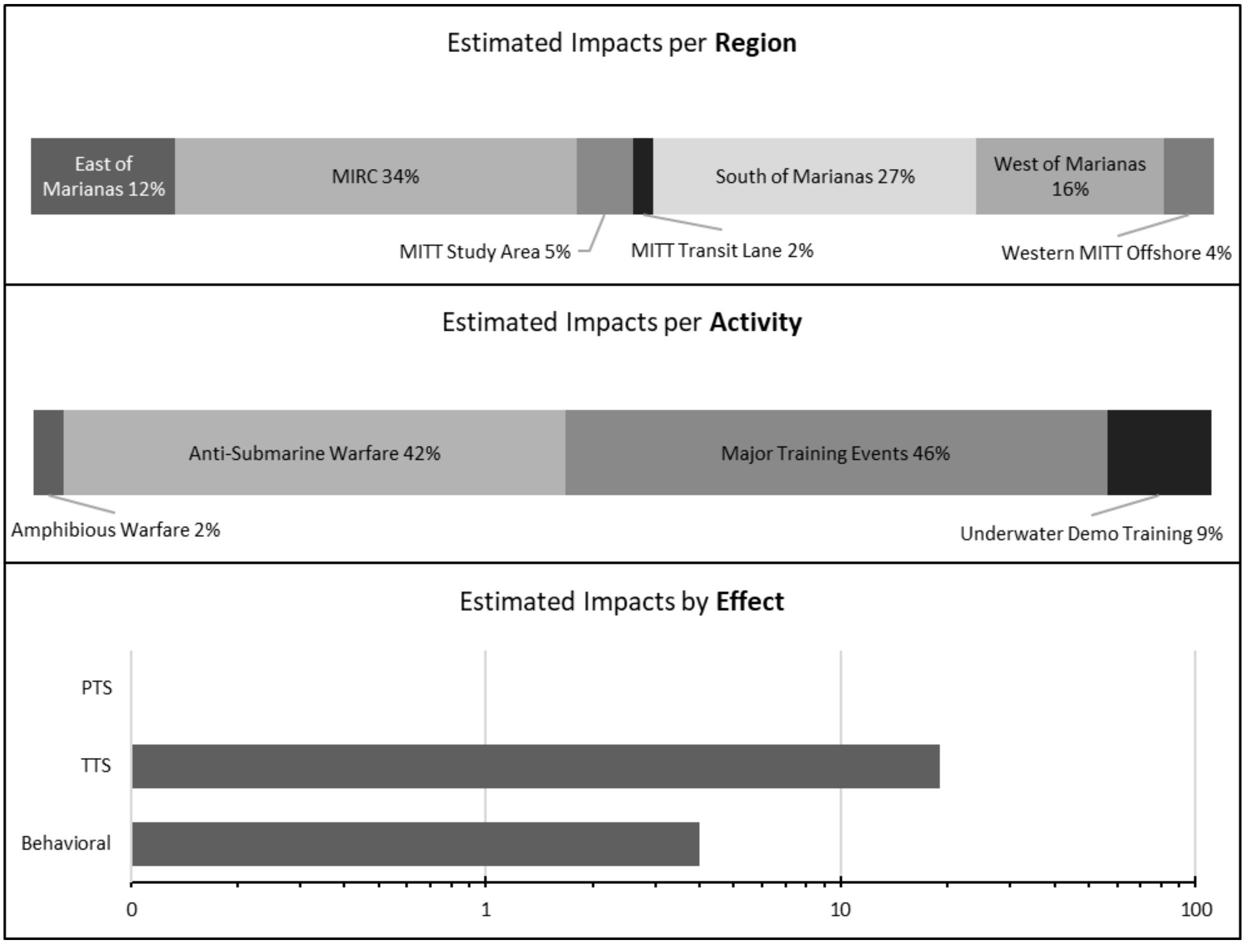
Blue Whale (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Blue whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-11 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). For mysticetes, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of blue whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 may affect ESA-listed blue whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

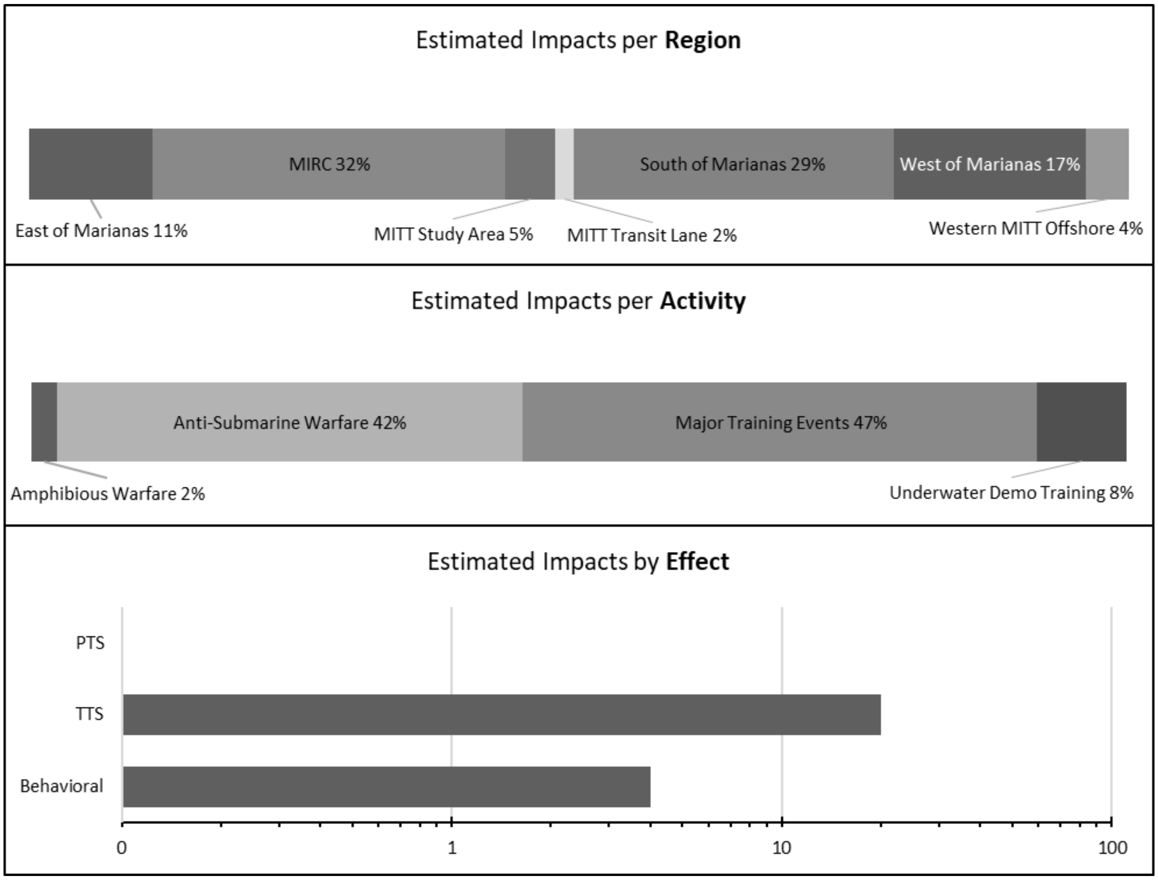
Figure 3.4-11: Blue Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Blue whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-12 or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as Alternative 1, although the numbers of impacts would increase slightly based on the increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of blue whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 may affect ESA-listed blue whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

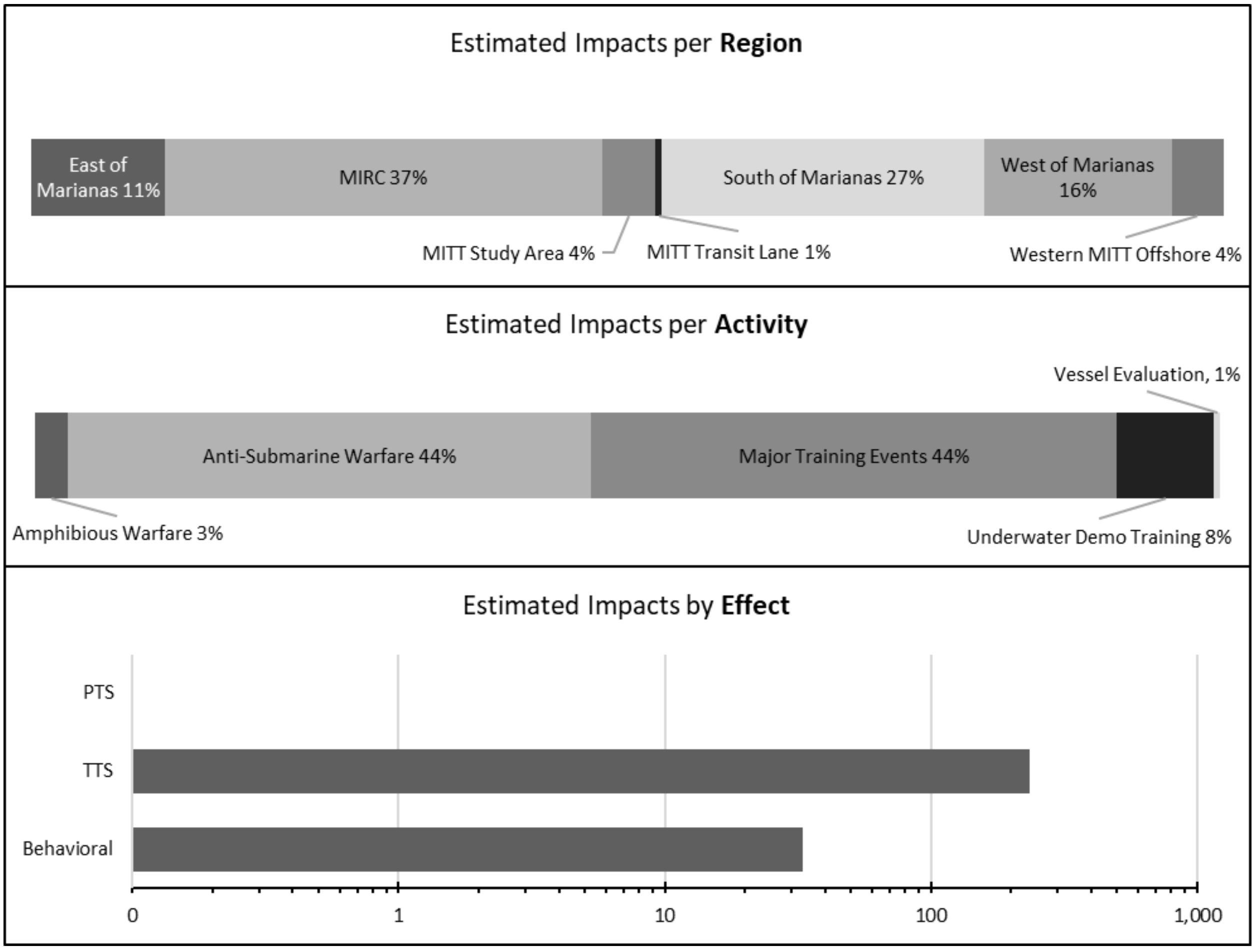
Figure 3.4-12: Blue Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Bryde's Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Bryde's whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-13 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Bryde's whales incidental to those activities.



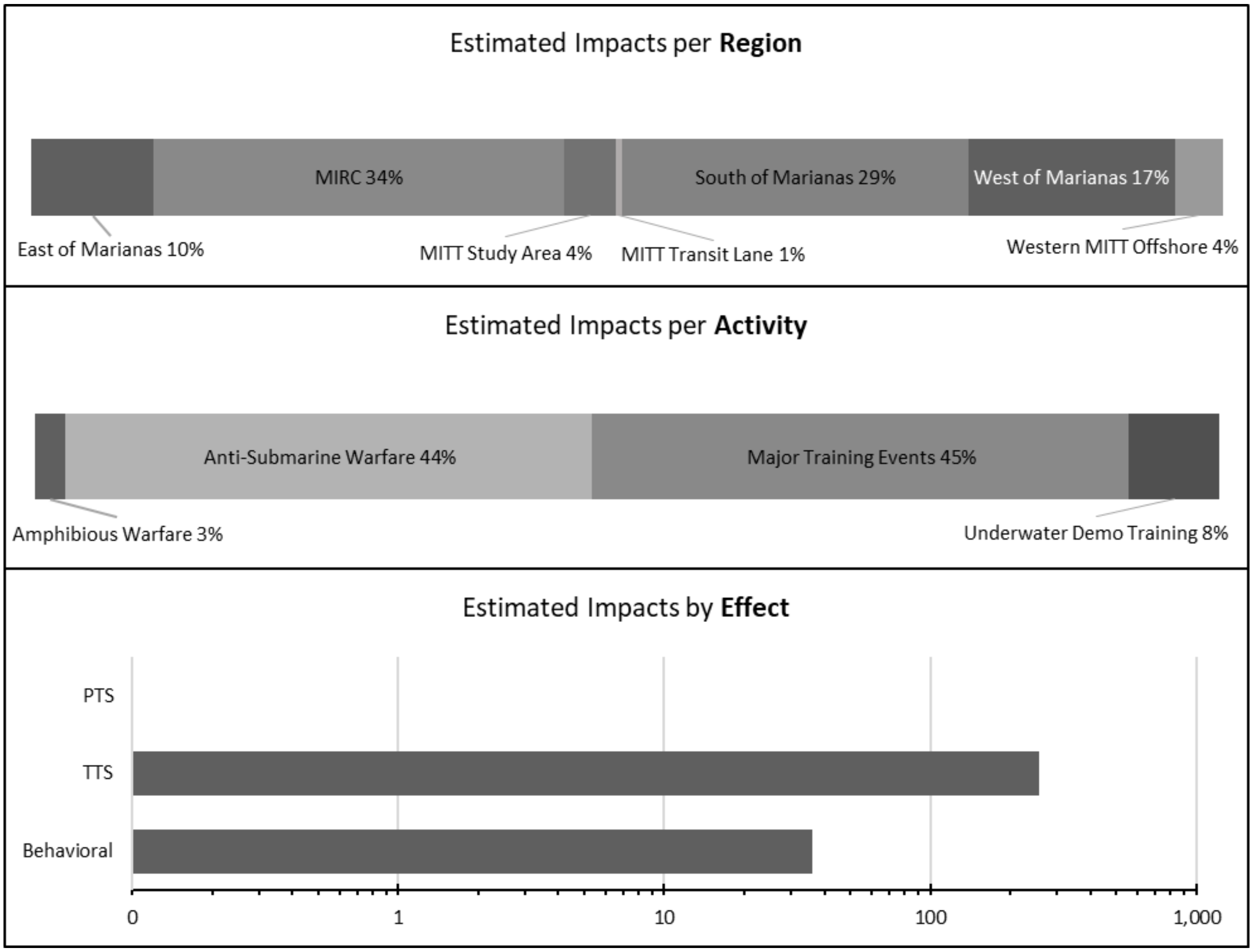
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-13: Bryde's Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Bryde's whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-14 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Bryde's whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-14: Bryde's Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

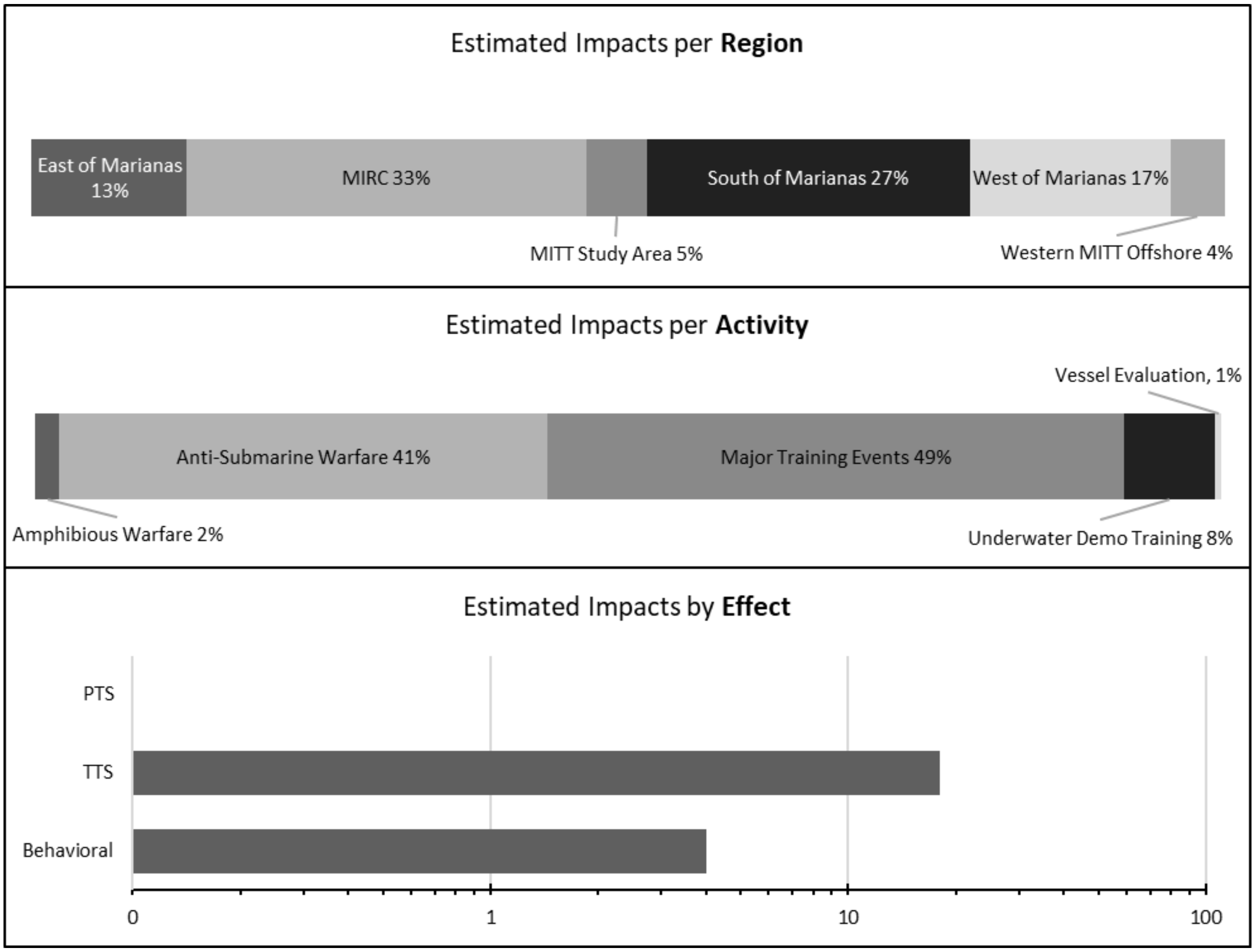
Fin Whale (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Fin whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-15 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of fin whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 may affect ESA-listed fin whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

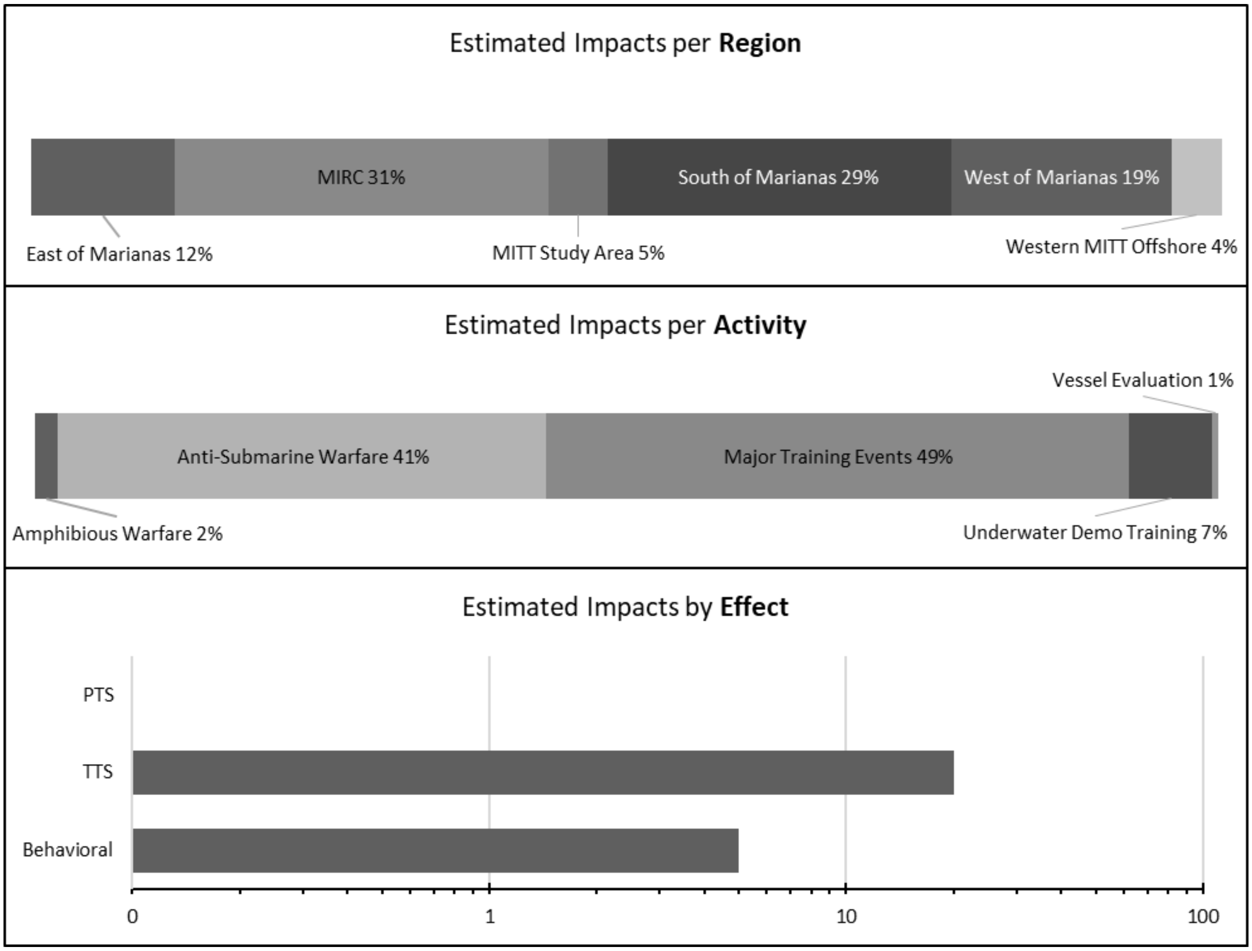
Figure 3.4-15: Fin Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Fin whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-16 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of fin whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 may affect ESA-listed fin whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-16: Fin Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Humpback Whale (Endangered Species Act-Listed)

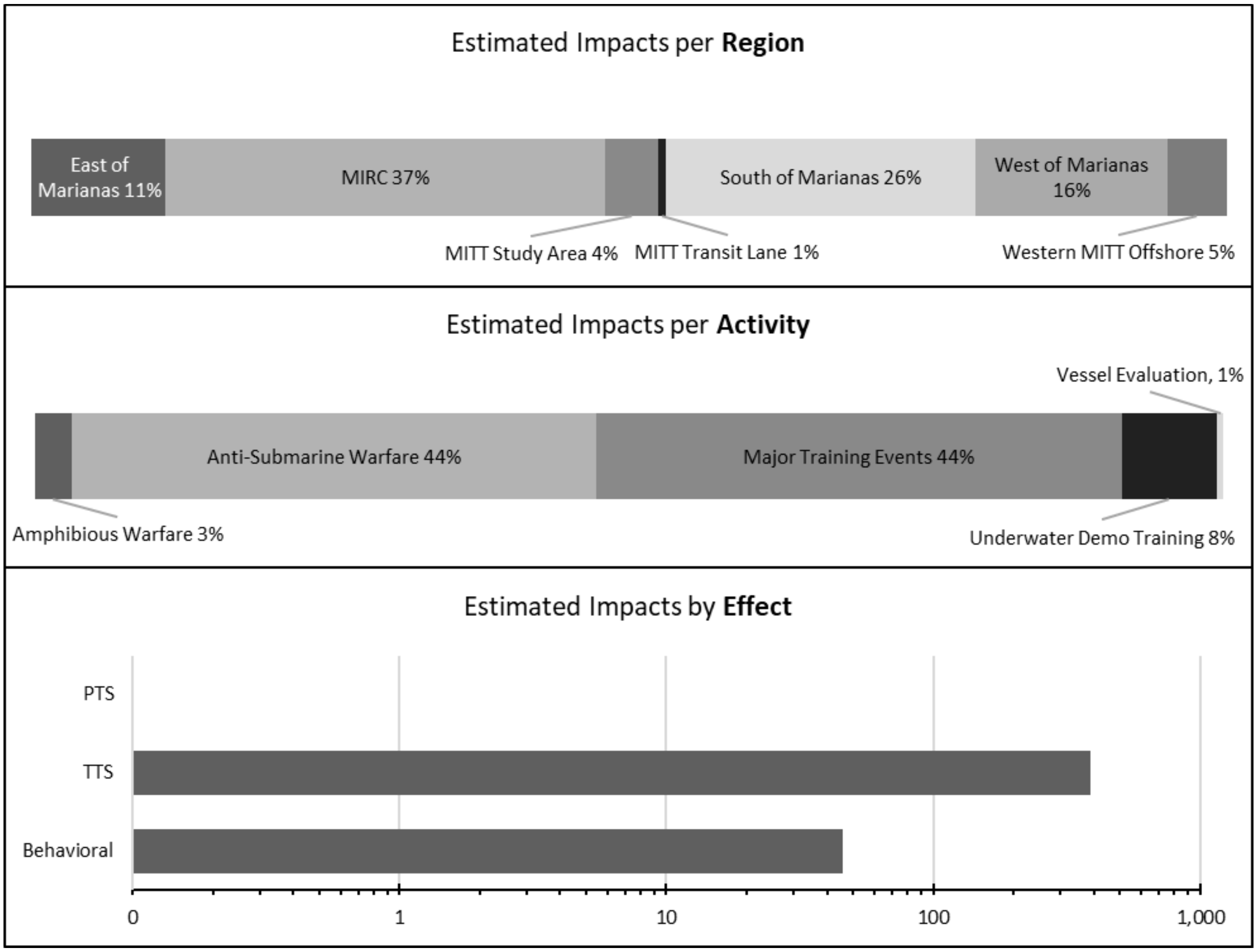
Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Humpback whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-17 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) or tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact

Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of humpback whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 may affect ESA-listed humpback whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-17: Humpback Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

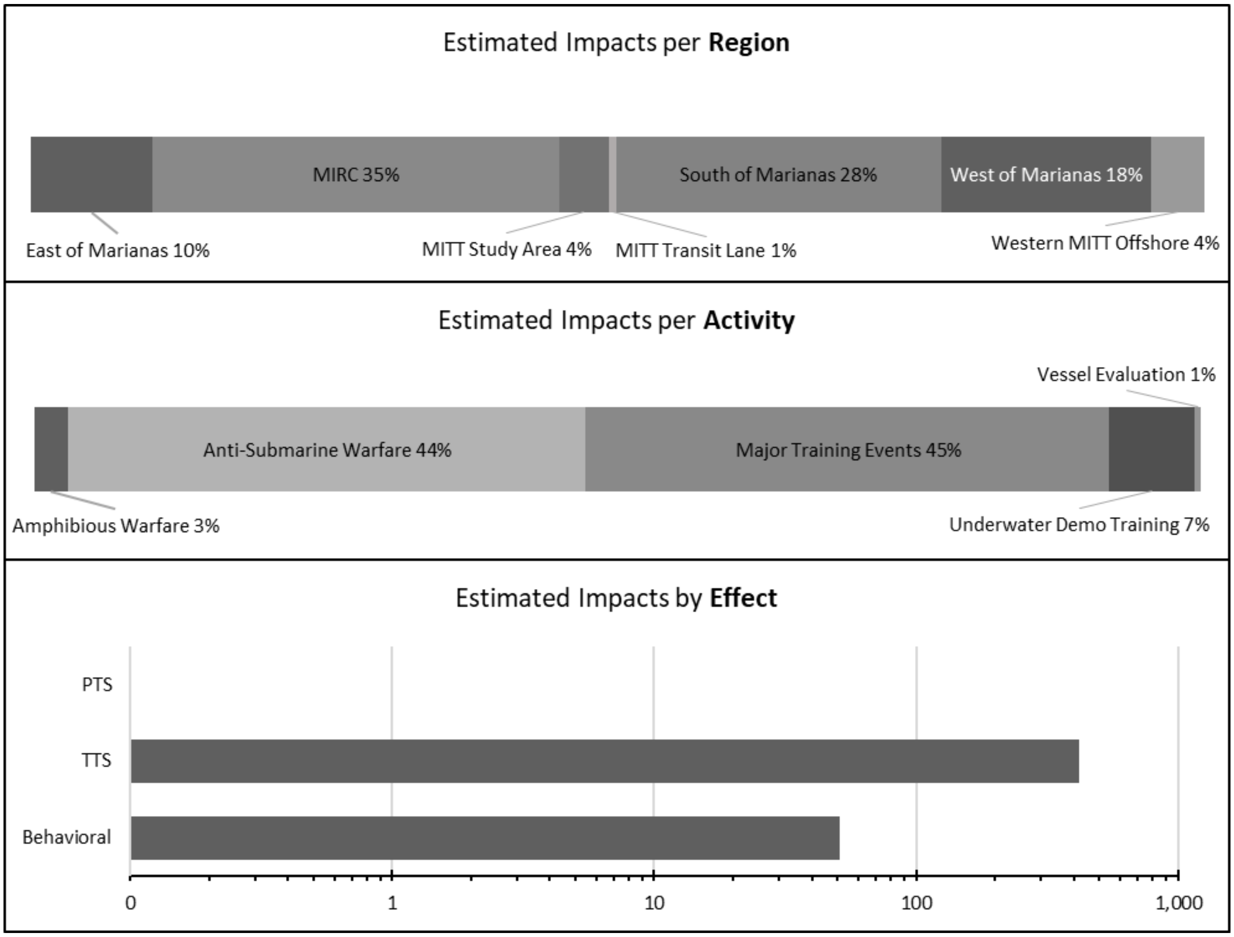
Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Humpback whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-18 below or Appendix E (Estimated Marine Mammal and Sea

Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of humpback whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 may affect ESA-listed humpback whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

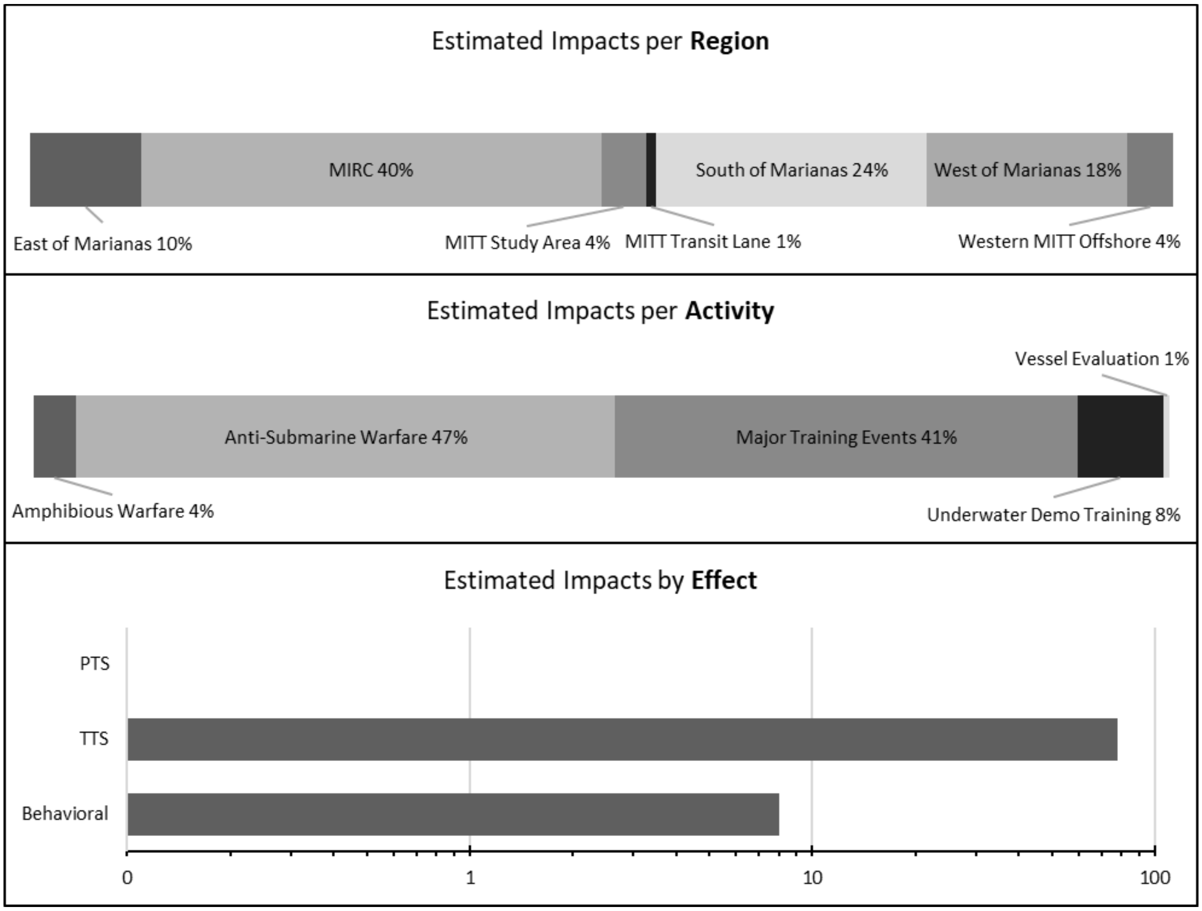
Figure 3.4-18: Humpback Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Minke Whale

<u>Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities</u>

Minke whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-19 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of minke whales incidental to those activities.



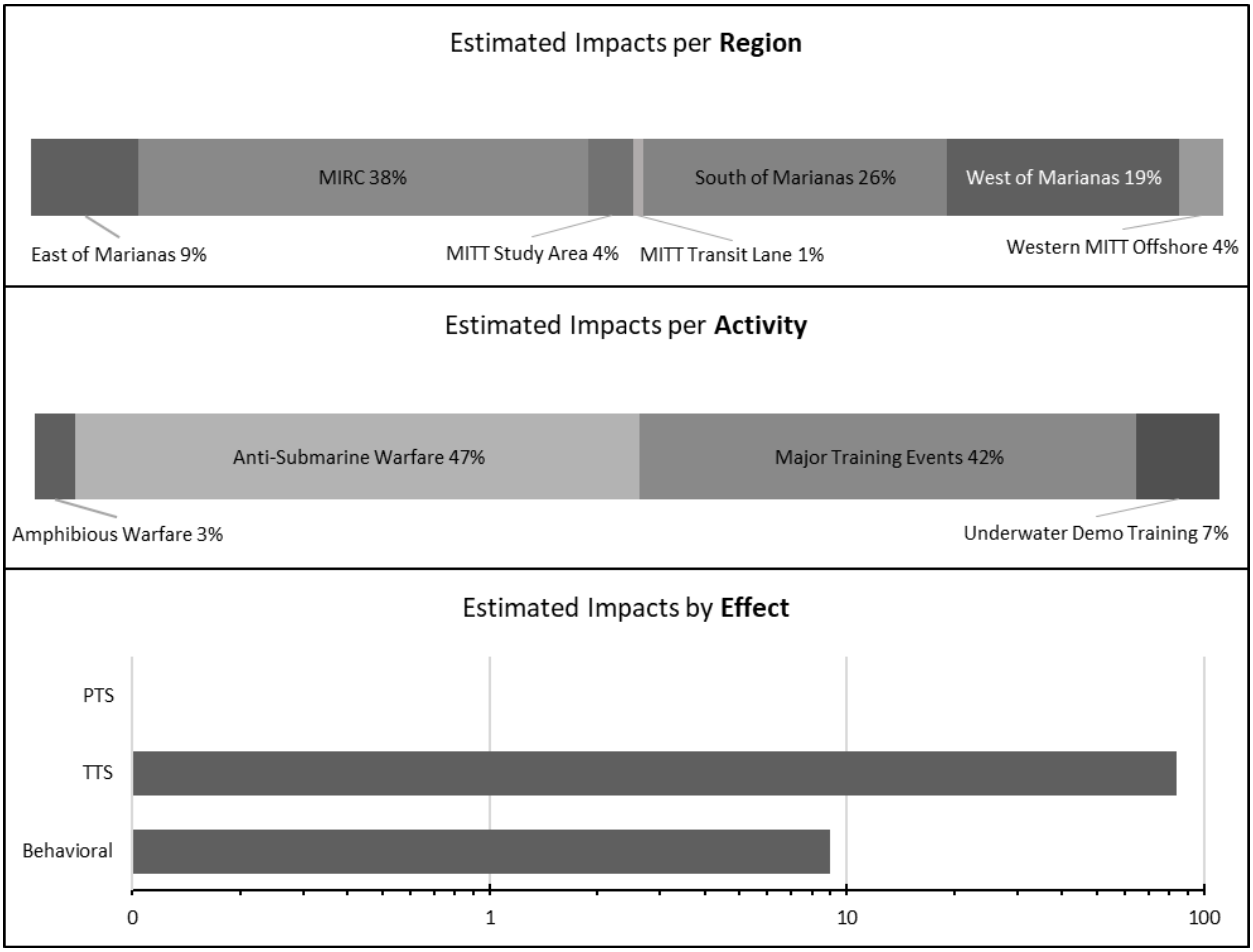
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-19: Minke Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Minke whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-20 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of minke whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

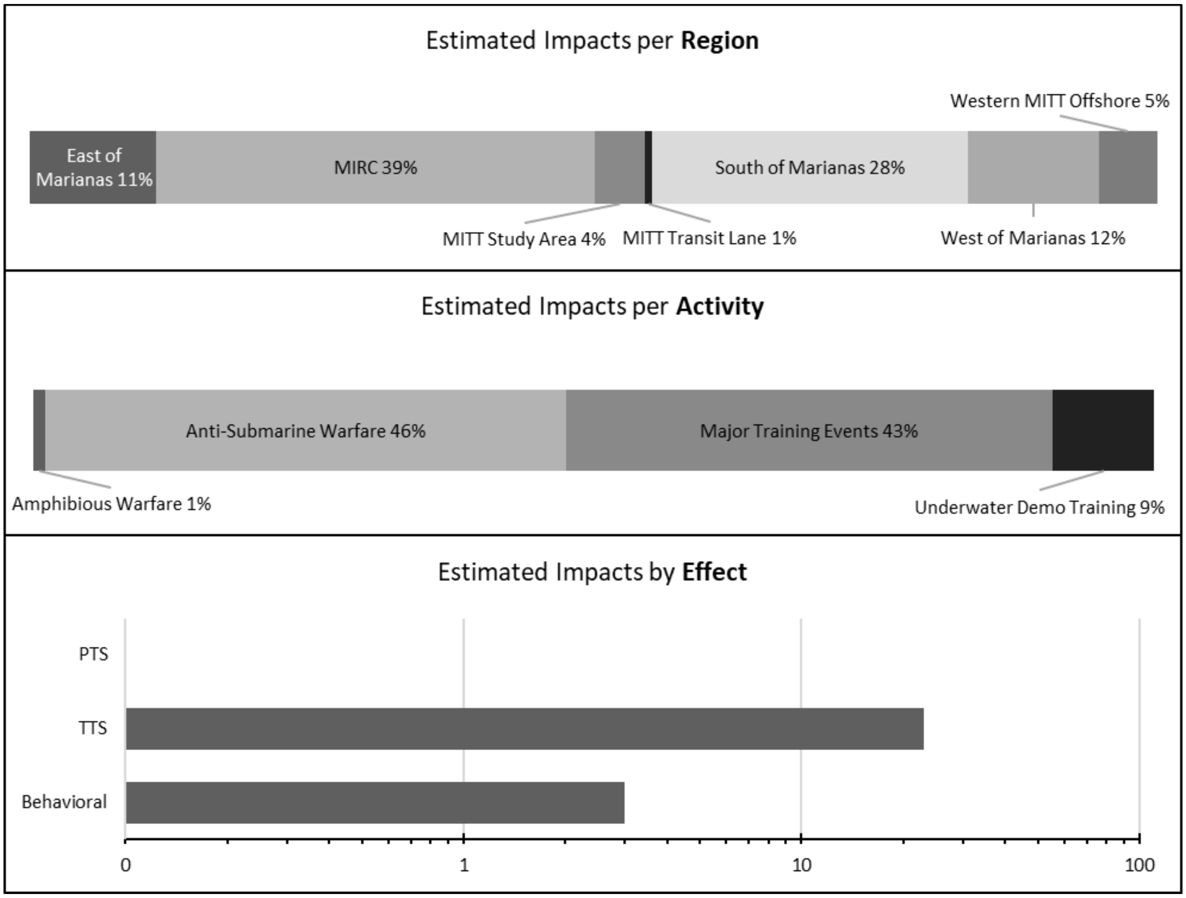
Figure 3.4-20: Minke Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Omura's Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and testing Activities

Omura's whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-21 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Omura's whales incidental to those activities.



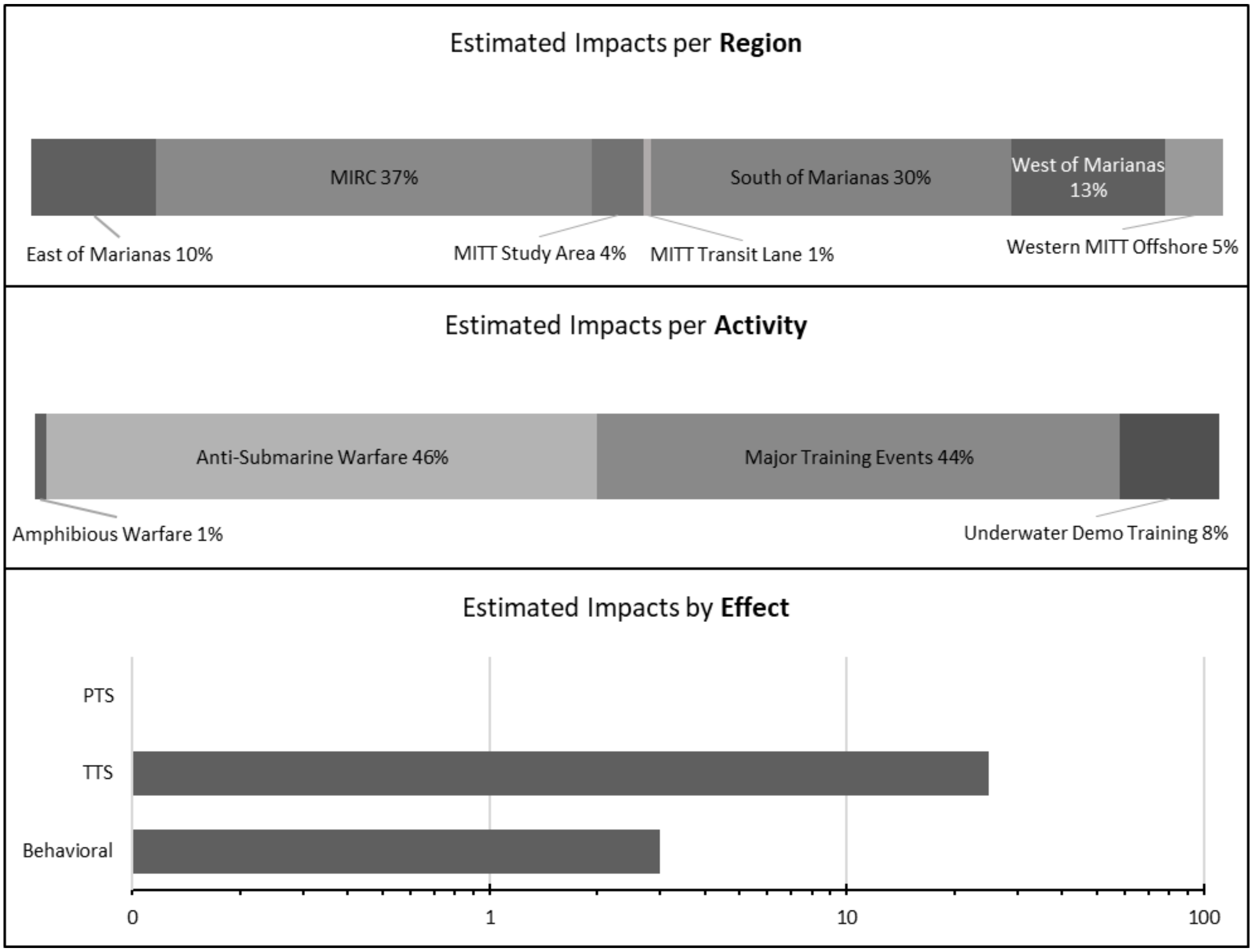
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-21: Omura's Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Omura's whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-22 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Omura's whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-22: Omura's Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

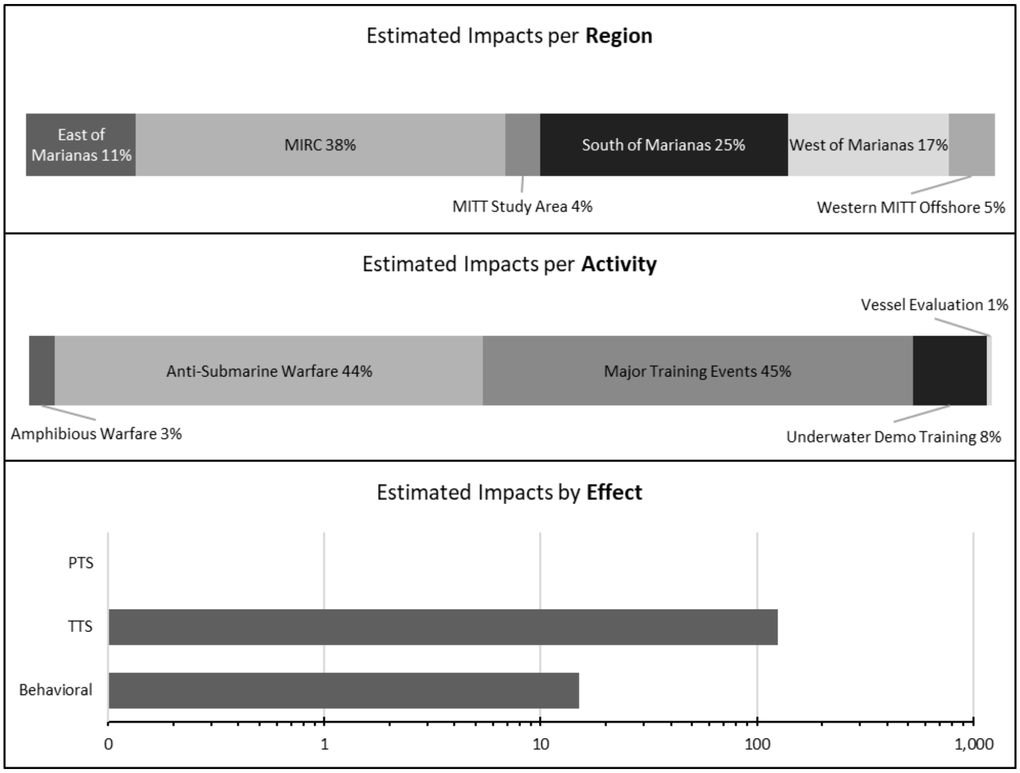
Sei Whale (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Sei whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-23 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of sei whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 may affect ESA-listed sei whales.



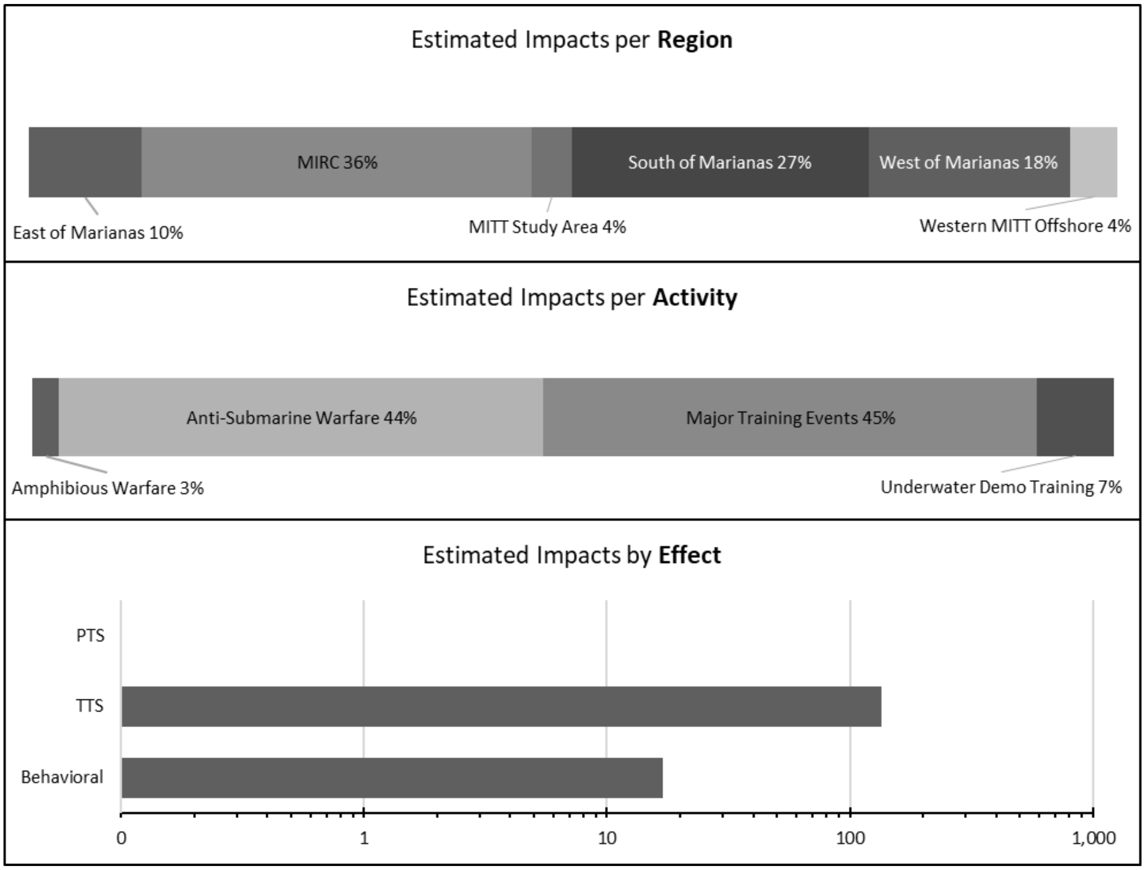
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-23: Sei Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Sei whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-24 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of sei whales incidental to those activities.
Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 may affect ESA-listed sei whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-24: Sei Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Odontocetes

Odontocetes may be exposed to sound from sonar and other transducers associated with training and testing activities throughout the year. Low- (less than 1 kHz), mid- (1–10 kHz), high-frequency (10–100 kHz), and very high-frequency (100–200 kHz) sonars produce sounds that are likely to be within the audible range of odontocetes (see Section 3.4.1.6, Hearing and Vocalization). If a sound is within an animal's hearing range then behavioral reactions, physiological stress, masking and hearing loss are potential impacts that must be analyzed. If a marine mammal cannot hear a sound, then behavioral reactions, physiological stress, masking, or hearing loss could not occur. Impact ranges for odontocetes are discussed under mid-frequency cetaceans in Section 3.4.2.1.2 (Impacts from Sonar and Other Transducer Stressors).

A few behavioral reactions in odontocetes (except beaked whales) resulting from exposure to sonar could take place at distances of up to 20 km. Beaked whales have demonstrated a high level of sensitivity to human-made noise and activity; therefore, the quantitative analysis assumes that some beaked whales could experience significant behavioral reactions at distance of up to 50 km from the sound source. Behavioral reactions, however, are much more likely within a few kilometers of the sound source for most species of odontocetes such as delphinids and sperm whales. Even for beaked whales, as discussed above in *Assessing the Severity of Behavioral Responses from Sonar*, the quantitative analysis very likely overestimated the numbers of behavioral reactions due to the underlying nature of the data used to derive the behavioral response functions.

Research shows that if odontocetes do respond they may react in a number of ways, depending on the characteristics of the sound source and their experience with the sound source. Behavioral reactions may include alerting; breaking off feeding dives and surfacing; or diving or swimming away. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Therefore, most behavioral reactions from odontocetes are likely to be short-term and low to moderate severity.

Large odontocetes such as killer whales and pilot whales have been the subject of behavioral response studies (see Section 3.4.2.1.1.5, Behavioral Reactions). Based on these studies, a number of reactions could occur such as a short-term cessation of natural behavior such as feeding, avoidance of the sound source, or even attraction towards the sound source as seen in pilot whales. Due to the factors involved in Navy training exercises versus the conditions under which pilot whales and killer whales were exposed during behavioral response studies, large odontocetes are unlikely to have more than short-term and moderate severity reactions to sounds from sonar or other human disturbance, and typically only at ranges within a few kilometers. Most estimated impacts are due to anti-submarine warfare activities, which could vary in duration and intensity. Anti-submarine warfare unit-level exercises and maintenance typically last for a matter of a few hours and involves a limited amount of sonar use so significant responses would be less likely than with longer and more intense exercises (more sonar systems and vessels). Coordinated/integrated anti-submarine warfare exercises involve multiple sonar systems and can last for a period of days, making significant response more likely. A single or few short-lived TTS or behavioral reactions per year are unlikely to have any significant costs or long-term consequences for individuals.

Small odontocetes have been the subject of behavioral response studies and observations in the field (see Section 3.4.2.1.1.5, Behavioral Reactions). Based on these studies, small odontocetes (dolphins) appear to be less sensitive to sound and human disturbance than other cetacean species. If reactions did occur, they could consist of a short-term behavior response such as cessation of feeding, avoidance of the sound source, or even attraction towards the sound source. Small odontocetes are unlikely to have more than short-term and moderate severity reactions to sounds from sonar or other human disturbance, and typically only at ranges within a few kilometers. Most estimated impacts are due to anti-submarine warfare activities, which could vary in duration and intensity. Anti-submarine warfare unit-level exercises and maintenance typically last for a matter of a few hours and involve a limited amount of sonar use so significant responses would be less likely than with longer and more intense exercises (more sonar systems and vessels). Coordinated/integrated anti-submarine warfare exercises involve multiple sonar systems and can last for a period of days, making significant response more likely. Some bottlenose dolphin estimated impacts could also occur due to navigation and object avoidance (detection) since these activities typically occur entering and leaving Navy homeports that overlap the distribution of coastal populations of this species. Navigation and object avoidance (detection) activities normally involve a single ship or submarine using a limited amount of sonar, therefore significant reactions are unlikely. A single or few short-lived TTS or behavioral reactions per year are unlikely to have any significant costs or long-term consequences for individuals.

Some odontocetes may avoid larger activities such as a major training exercise as it moves through an area. Vessels and aircraft associated with training or testing activities are typically in transit during an event (they are not stationary) and activities typically do not use the same training locations day-after-day during multi-day activities. If an event otherwise focuses on a fixed location, sensitive species of odontocetes, such as beaked whales, may avoid the location of the activity for the duration of the event. Section 3.4.2.1.1.5 (Behavioral Reactions) discusses these species' observed reactions to sonar and other transducers. If animals are displaced, they would likely return after the sonar activity subsides within an area, as seen in Blainville's beaked whales in the Bahamas (Tyack et al., 2011) and Hawaii (Henderson et al., 2015b; Henderson et al., 2016; Manzano-Roth et al., 2016). This would allow the animal to recover from any energy expenditure or missed resources, reducing the likelihood of long-term consequences for the individual. It is unlikely that most individuals would encounter a major training exercise more than once per year due to where these activities are typically conducted. Outside of Navy instrumented ranges and homeports, the use of sonar and other transducers is transient and is unlikely to expose the same population of animals repeatedly over a short period. However, a few behavioral reactions per year from a single individual are unlikely to produce long-term consequences for that individual.

Behavioral research indicates that most odontocetes avoid sound sources at levels that would cause any temporary hearing loss (i.e., TTS) (see Section 3.4.2.1.1.5, Behavioral Reactions). TTS and even PTS is more likely for high-frequency cetaceans, such as Kogia whales, because hearing loss thresholds for these animals are lower than for all other marine mammals. These species have demonstrated a high level of sensitivity to human-made sound and activities and may avoid at further distances. This increased distance could avoid or minimize hearing loss for these species as well, especially as compared to the estimates from the quantitative analysis. Therefore, it is likely that the quantitative analysis overestimates TTS and PTS in marine mammals because it does not account for animals avoiding sound sources at closer ranges. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. TTS would be recoverable and PTS would leave some residual hearing loss. Most TTS, if it does actually occur, would be more likely to be minor to moderate (i.e., less than 20 dB of TTS directly after the exposure) and would recover within a matter of minutes to hours. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. During the period that an odontocete had hearing loss, social calls from conspecifics could be more difficult to detect or interpret. Killer whales are a primary predator of odontocetes. Some hearing loss could make killer whale calls more difficult to detect at further ranges until hearing recovers. Odontocetes use echolocation clicks to find and capture prey. These echolocation clicks and vocalizations are at frequencies above a few tens of kHz for delphinids, beaked whales, and sperm whales, and above 100 kHz for Kogia whales. Therefore, echolocation associated with feeding and navigation in odontocetes is unlikely to be affected by threshold shift at lower frequencies and should not have any significant effect on an odontocete's ability to locate prey or navigate, even in the short-term. Therefore, a single or even a few minor TTS (less than 20 dB of TTS) to an individual odontocete per year are unlikely to have any long-term consequences for that individual. Minor PTS (a few dB or less) in an individual could have no to minor long-term consequences for individuals.

Research and observations of masking in marine mammals are discussed in Section 3.4.2.1.1.4 (Masking). Many anti-submarine warfare sonars and countermeasures use low- and mid-frequency sonar. Most low- and mid-frequency sonar signals (i.e., sounds) are limited in their temporal, frequency, and spatial domains. The duration of most individual sounds is short, lasting up to a few seconds each. Some systems operate with higher duty cycles or nearly continuously, but typically use lower power. Nevertheless, masking may be more prevalent at closer ranges to these high-duty cycle and continuous active sonar systems. Most anti-submarine warfare activities are geographically dispersed and last for only a few hours, often with intermittent sonar use even within this period. Most anti-submarine warfare sonars also have a narrow frequency band (typically much less than one-third octave). These factors reduce the likelihood of sources causing significant masking in odontocetes due to exposure to sonar used during anti-submarine warfare activities. Odontocetes may experience some limited masking at closer ranges from high-frequency sonars and other transducers; however, the frequency band of the sonar is narrow, limiting the likelihood of masking. High-frequency sonars are typically used for mine hunting, navigation, and object detection (avoidance). Potential costs to odontocetes from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively pinging and the effect is over the moment the sound has ceased.

Nevertheless, odontocetes that do experience some masking from sonar or other transducers may have their ability to communicate with conspecifics reduced, especially at further ranges. Sounds from mid-frequency sonar could mask killer whale vocalizations making them more difficult to detect, especially at further ranges. As discussed above for TTS, odontocetes use echolocation to find prey and navigate. The echolocation clicks of odontocetes are above the frequencies of most sonar systems, especially those used during anti-submarine warfare. Therefore, echolocation associated with feeding and navigation in odontocetes is unlikely to be masked by sounds from sonars or other transducers. A single or even a few short periods of masking, if it were to occur, to an individual odontocete per year are unlikely to have any long-term consequences for that individual.

Beaked Whales

Beaked whales within the Study Area include: Blainville's beaked whale, Cuvier's beaked whale, ginkgo-toothed beaked whale, and Longman's beaked whale. As discussed above for odontocetes overall, the quantitative analysis overestimates hearing loss in marine mammals because behavioral response research has shown that most marine mammals are likely to avoid sound levels that could cause more than minor to moderate TTS (6–20 dB). Specifically for beaked whales, behavioral response research discussed below and in Section 3.4.2.1.1.5 (Behavioral Reactions) has demonstrated that beaked whales are sensitive to sound from sonars and usually avoid sound sources by 10 or more kilometers. These are well beyond the ranges to TTS for mid-frequency cetaceans such as beaked whales. Therefore, any TTS predicted by the quantitative analysis is unlikely to occur in beaked whales.

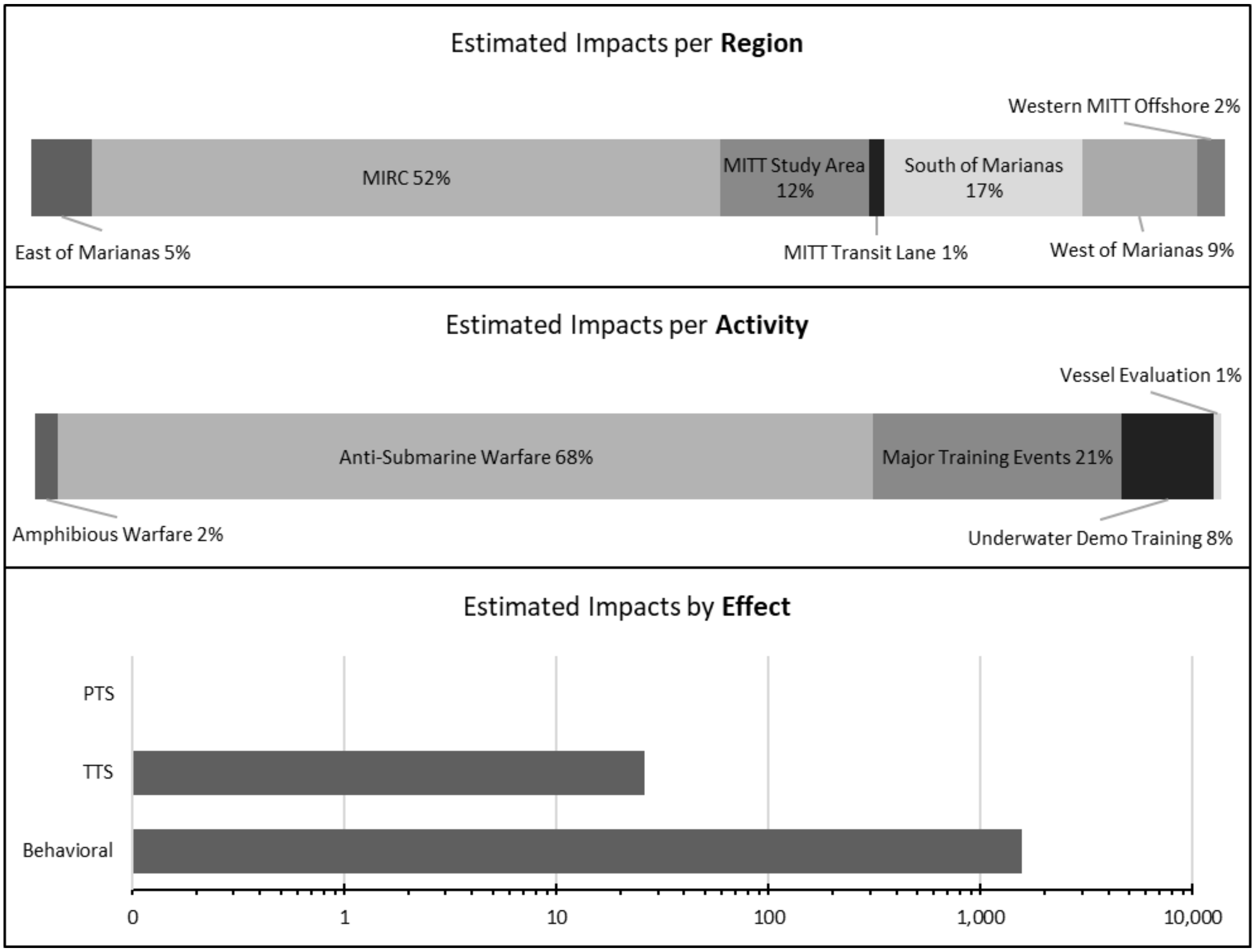
Research and observations (Section 3.4.2.1.1.5, Behavioral Reactions) show that if beaked whales are exposed to sonar or other transducers they may startle, break off feeding dives, and avoid the area of the sound source at levels ranging between 95 and 157 dB re 1 µPa (McCarthy et al., 2011). Furthermore, in research done at the Navy's fixed tracking range in the Bahamas and Hawaii, animals leave the immediate area of the anti-submarine warfare training exercise but return within a few days after the event ends (Henderson et al., 2015b; Henderson et al., 2016; Manzano-Roth et al., 2016; Tyack et al., 2011). Populations of beaked whales and other odontocetes on Navy fixed ranges that have been operating for decades appear to be stable, and analysis is ongoing. Significant behavioral reactions seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of kilometers, especially for prolonged periods (a few hours or more) since this is one of the most sensitive marine mammal groups to human-made sound of any species or group studied to date.

Based on the best available science, the Navy believes that beaked whales that exhibit a significant behavioral reaction due to sonar and other transducers 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." The Navy does not anticipate that marine mammal strandings or mortality would result from the operation of sonar during Navy 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 Navy activities and a future stranding.

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

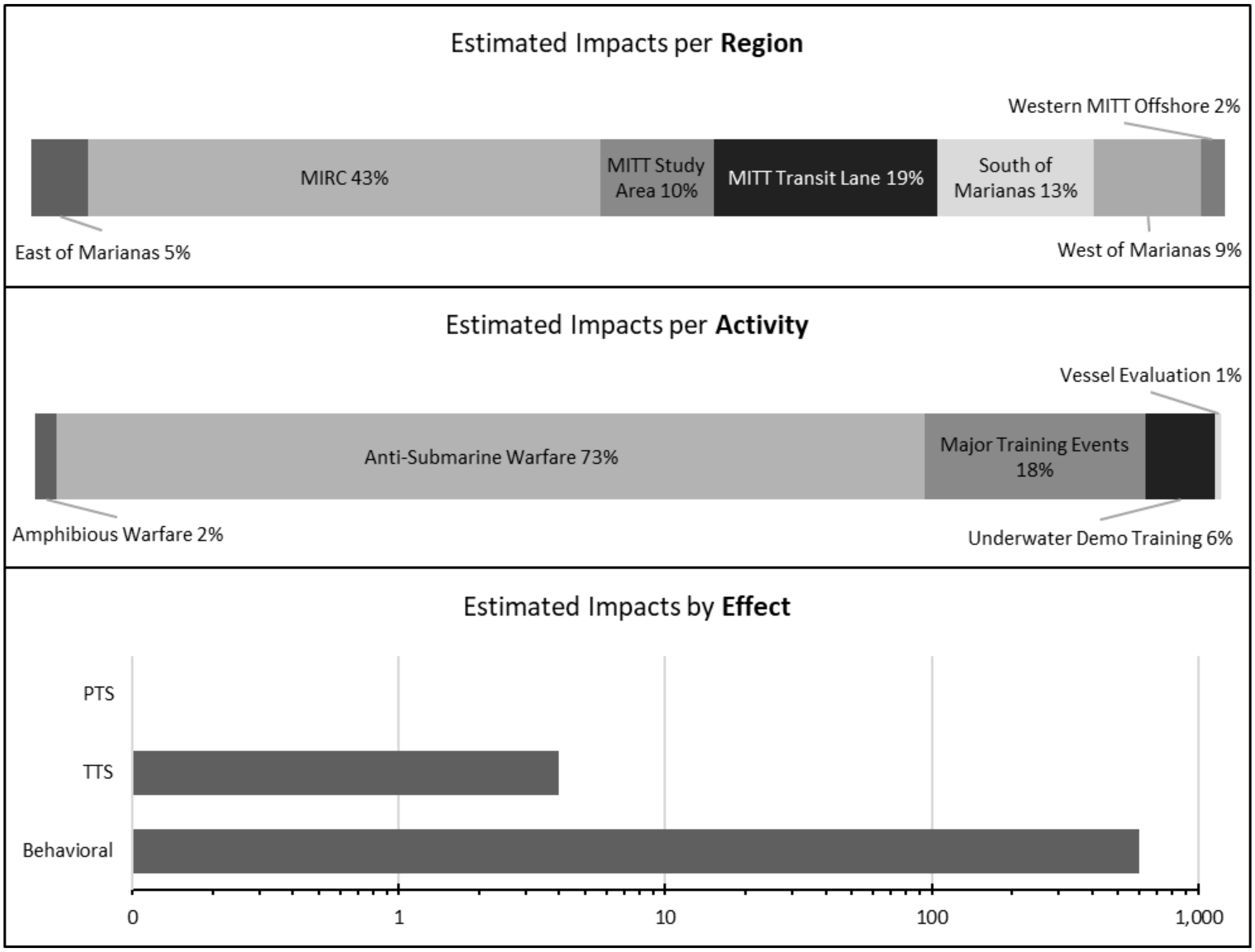
Beaked whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-25 through Figure 3.4-28 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Blainville's, Cuvier's, ginkgo-toothed, and Longman's beaked whales incidental to those activities.



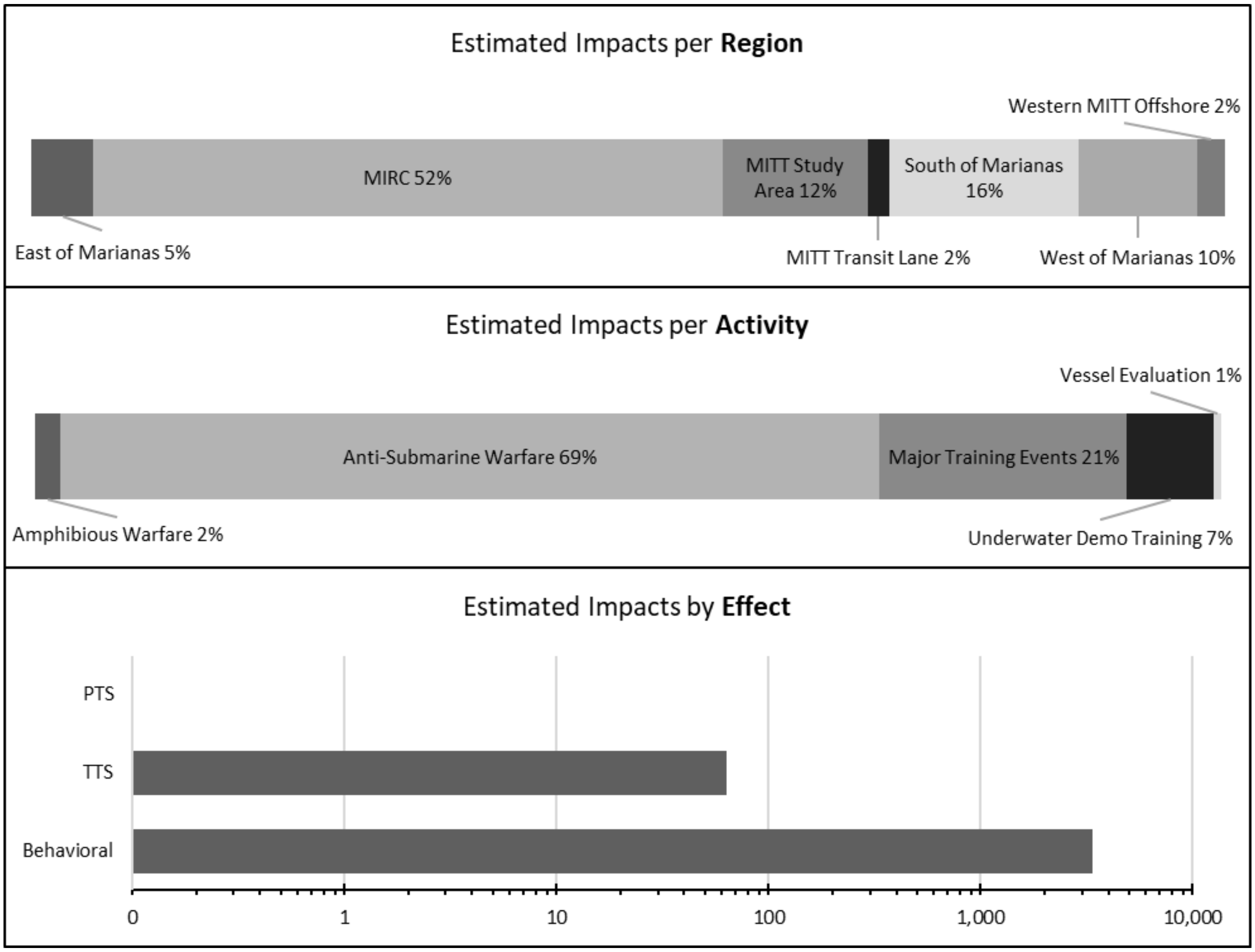
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-25: Blainville's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1



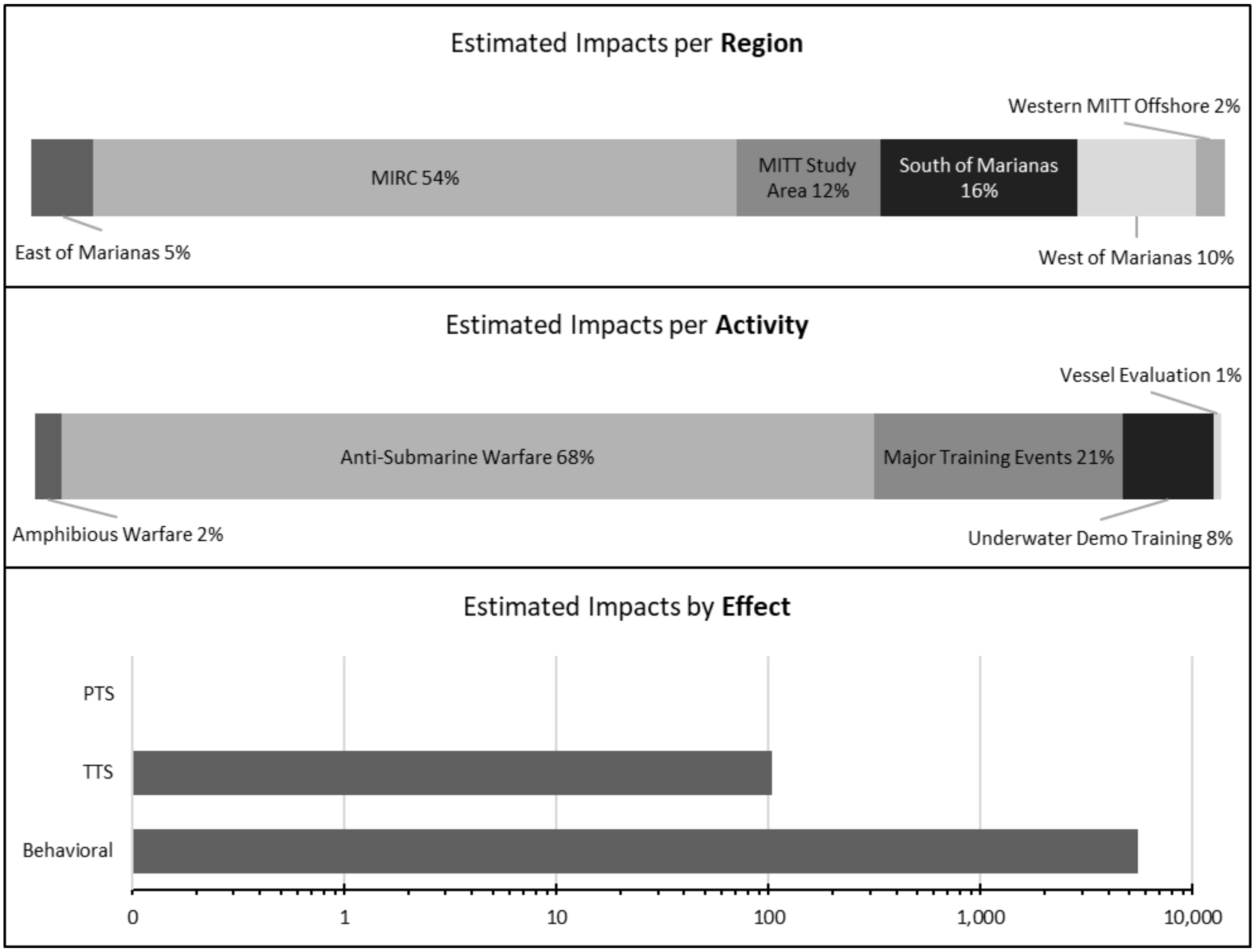
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-26: Cuvier's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-27: Ginkgo-Toothed Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1



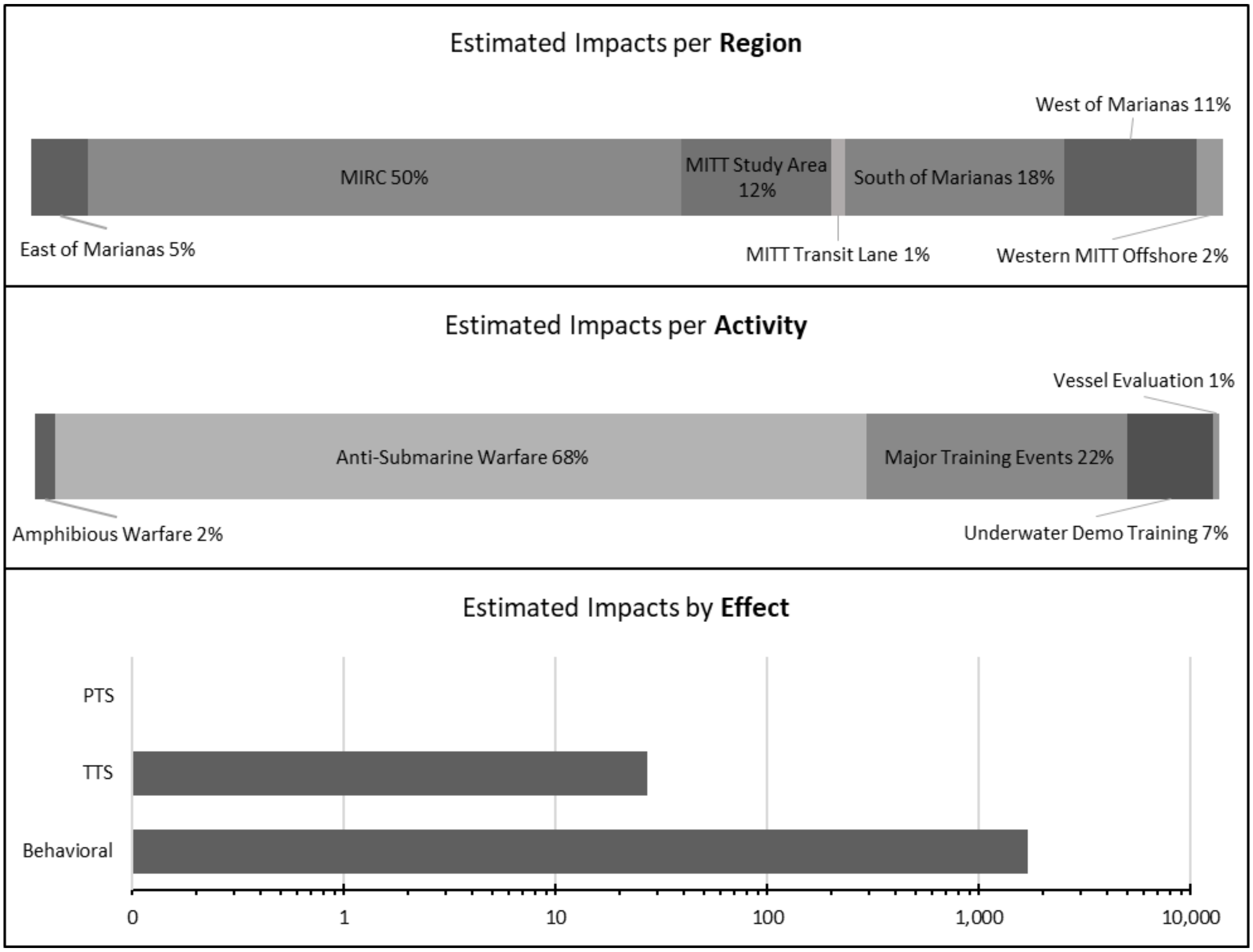
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-28: Longman's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

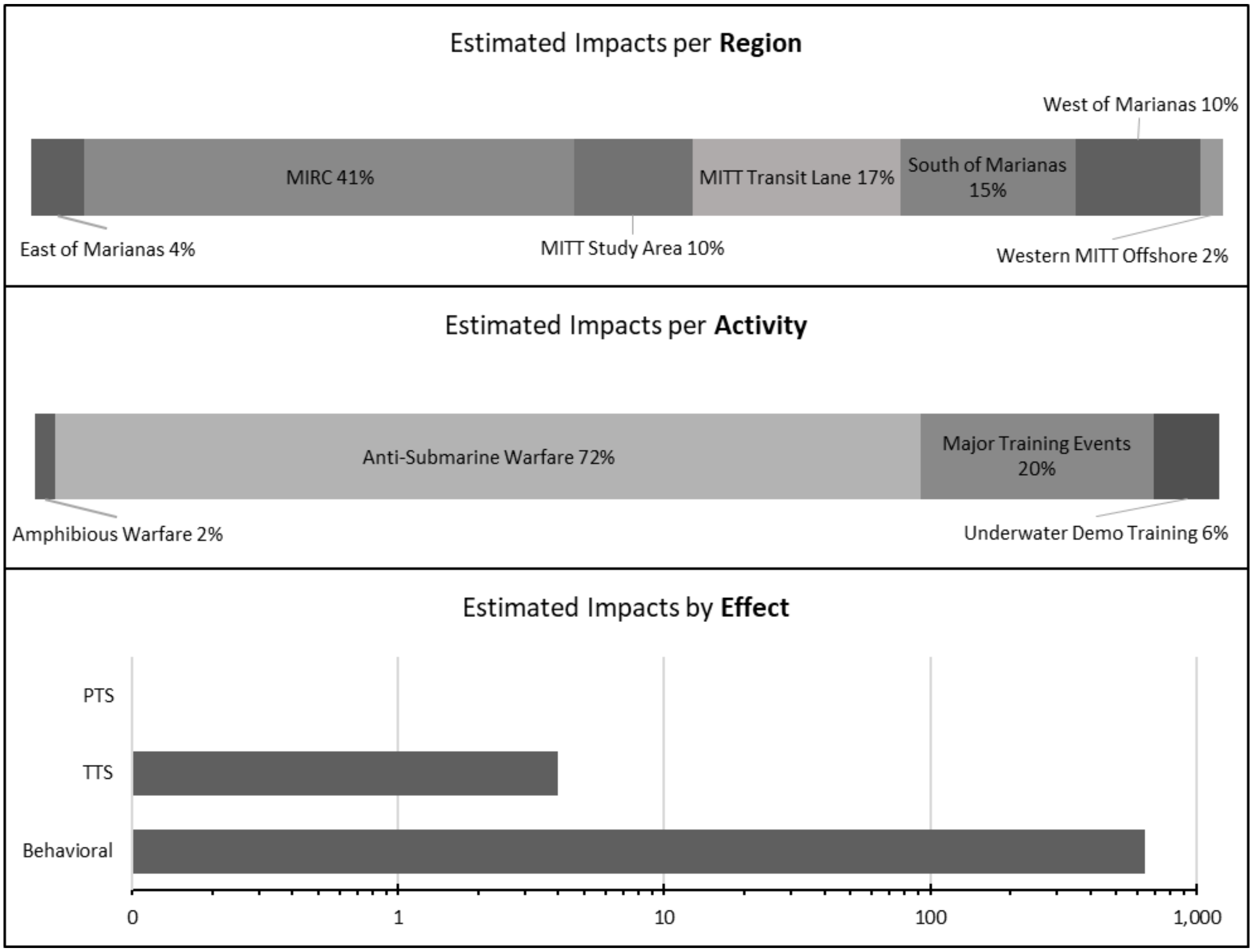
Beaked whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-29 through Figure 3.4-32 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Blainville's, Cuvier's, ginkgo-toothed, and Longman's beaked whales incidental to those activities.



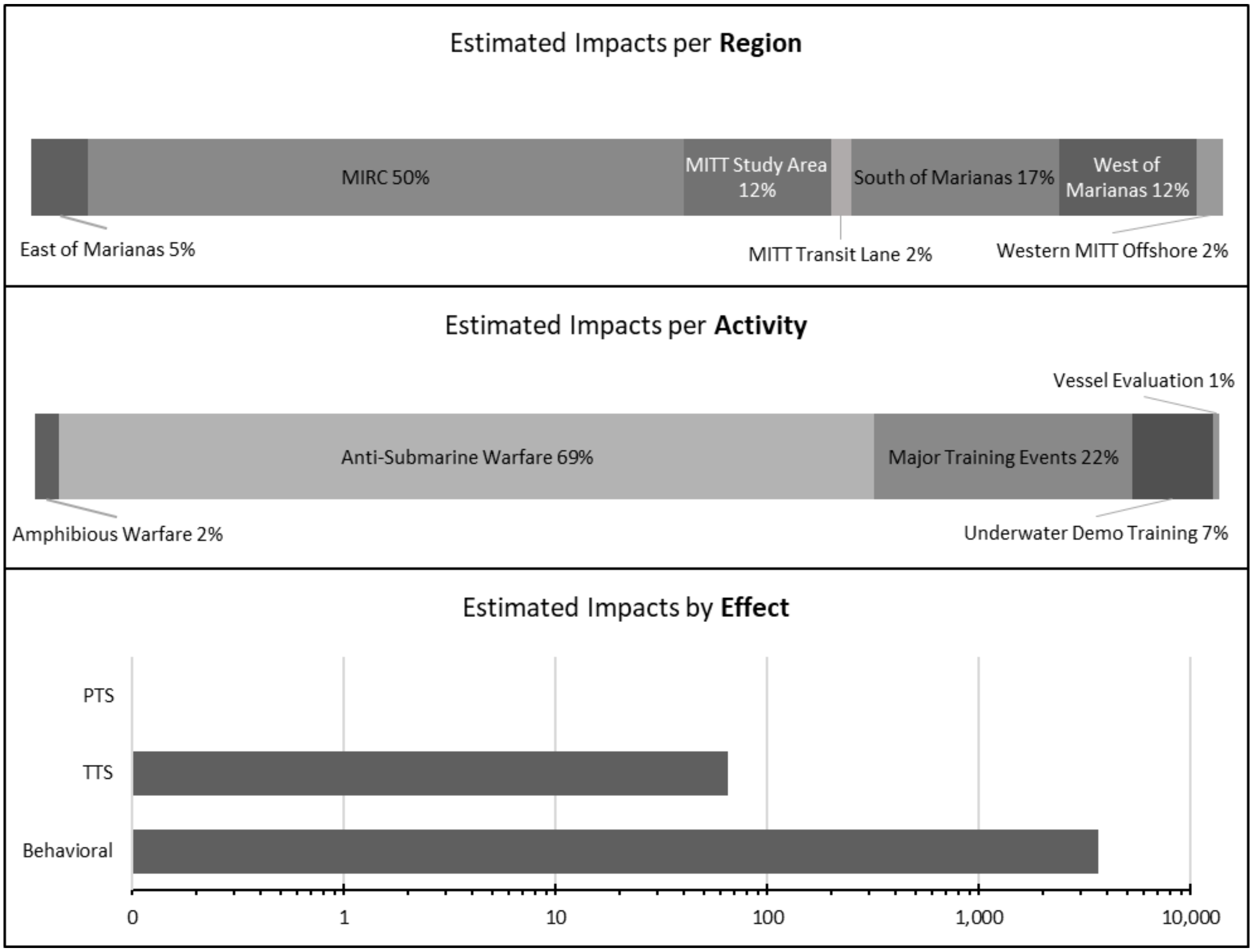
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-29: Blainville's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2



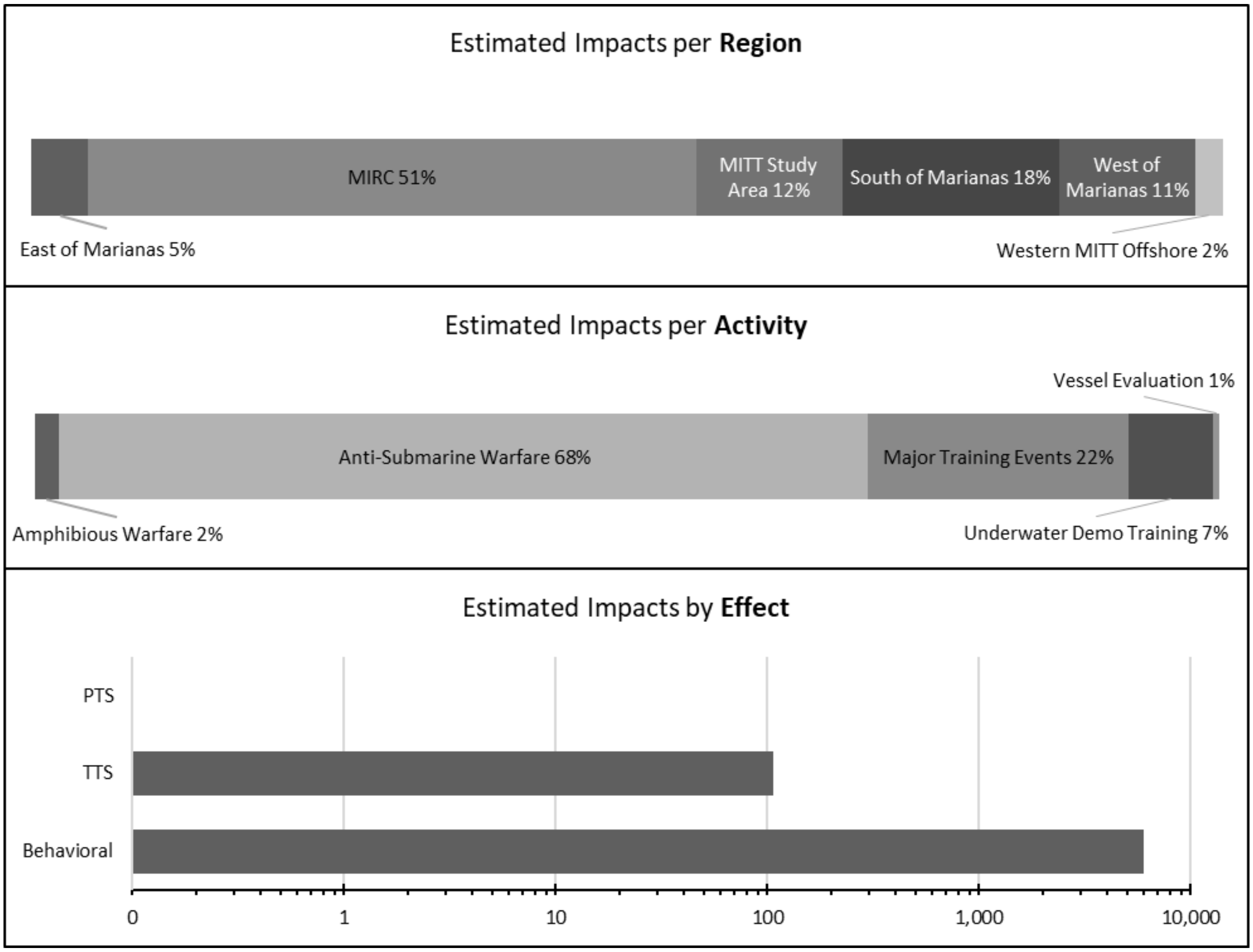
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-30: Cuvier's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-31: Ginkgo-Toothed Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

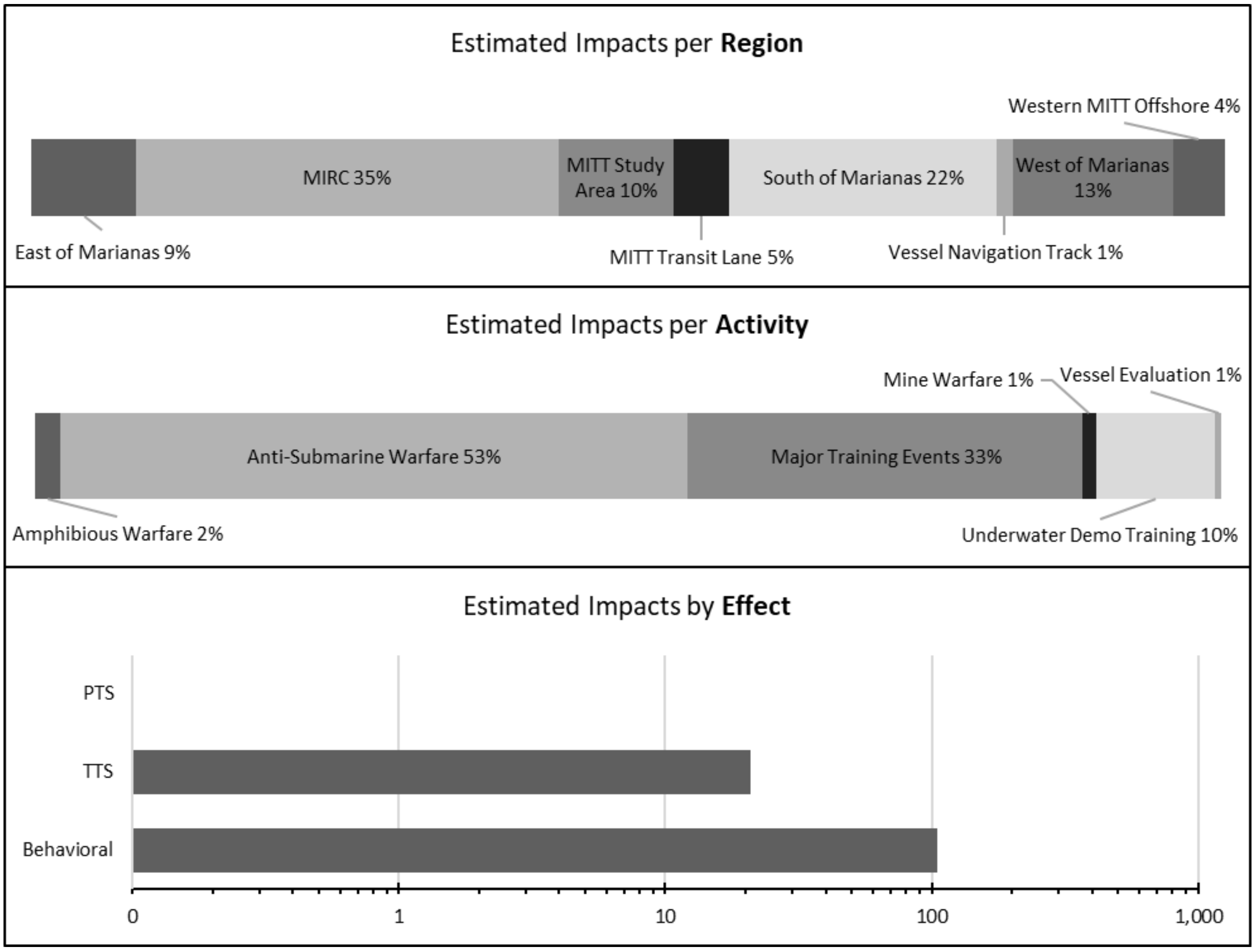
Figure 3.4-32: Longman's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Common Bottlenose Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Bottlenose dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-33 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of bottlenose dolphins incidental to those activities.



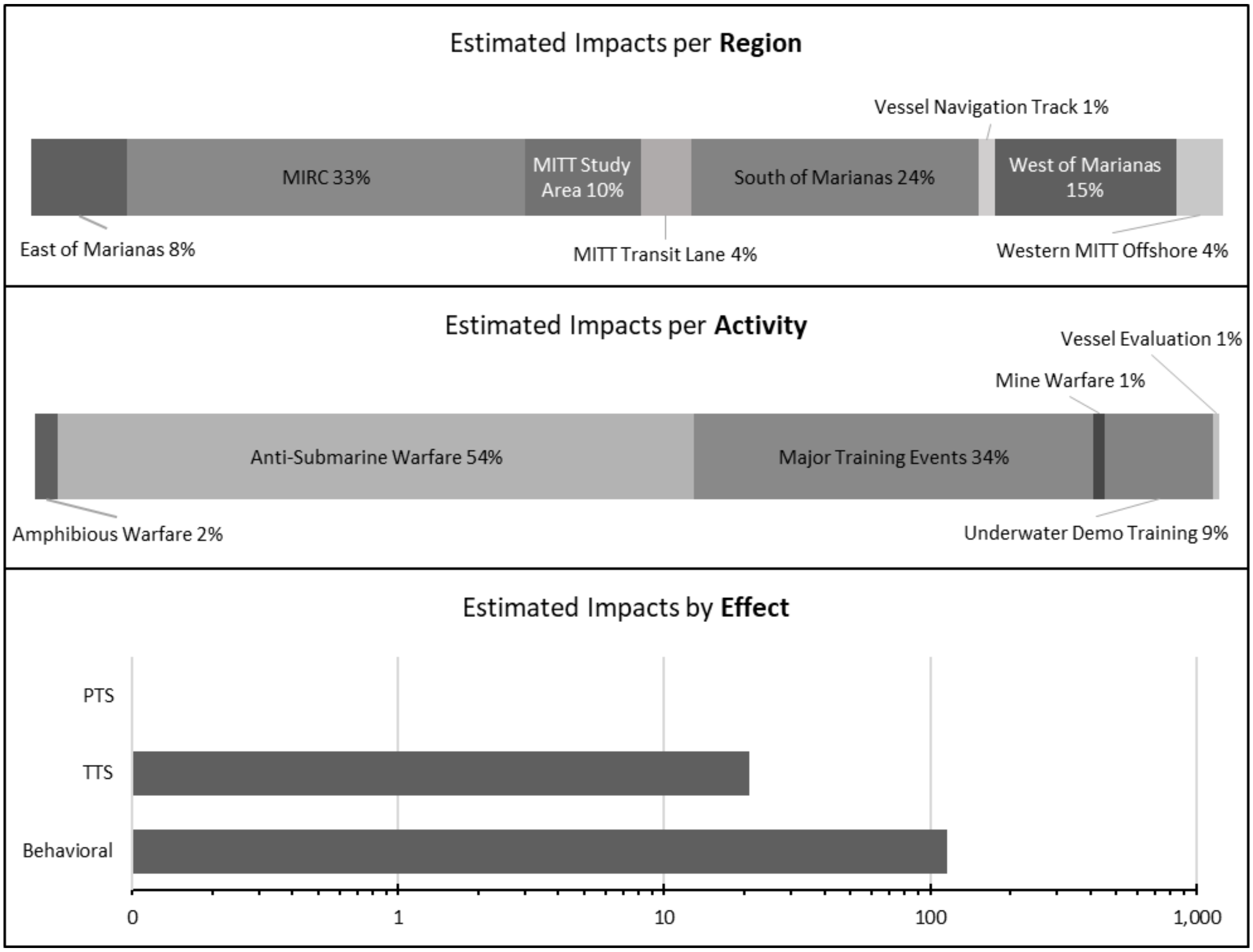
Note: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-33: Bottlenose Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Bottlenose dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-34 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of bottlenose dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-34: Bottlenose Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Kogia Whales

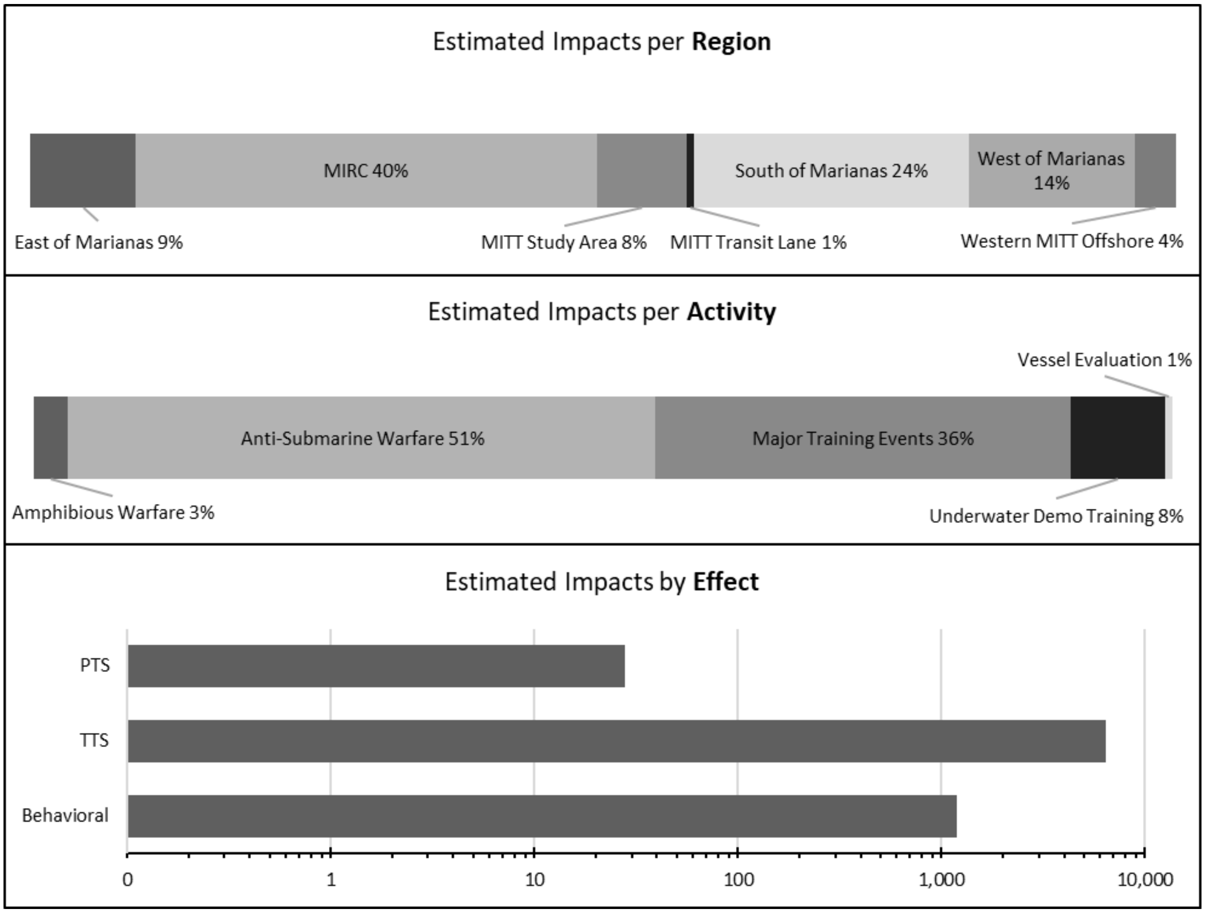
Kogia whales include two species that are often difficult to distinguish from one another: dwarf sperm whales and pygmy sperm whales; however, impacts to the populations of dwarf and pygmy sperm whales are modeled separately. TTS and PTS thresholds for high-frequency cetaceans, such as Kogia whales are lower than for all other marine mammals, which leads to a higher number of estimated hearing loss impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans).

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Kogia whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and

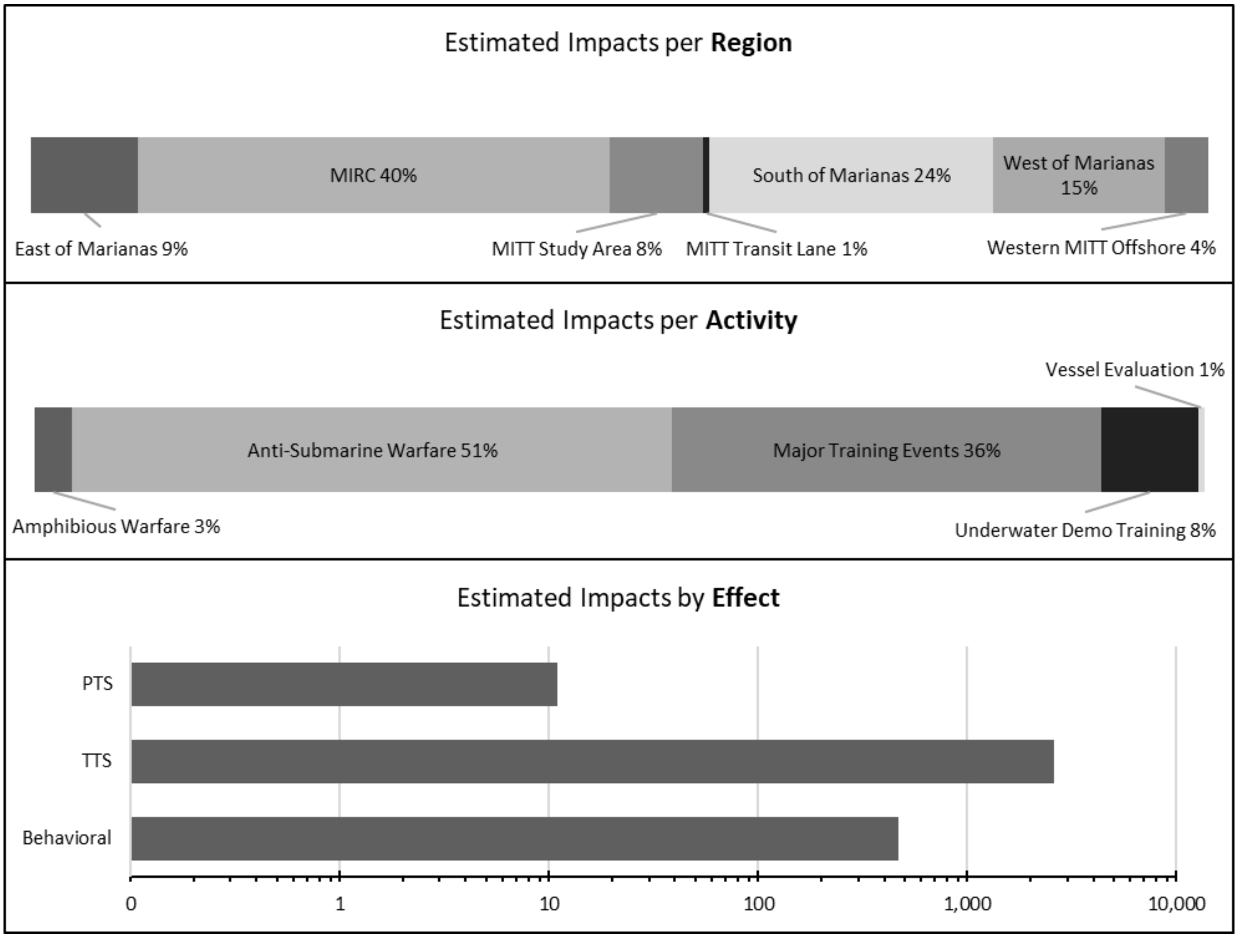
PTS under Alternative 1. See Figure 3.4-35 and Figure 3.4-36 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS could reduce an animal's ability to detect biologically important sounds; however, as discussed above, a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that Kogia whales rely upon. Nevertheless, PTS could have minor long-term consequences for individuals. This minor consequence for an individual is unlikely to have any long-term consequences for the species. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Kogia whales (i.e., dwarf and pygmy sperm whales) incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts.
(2) MIRC = Mariana Islands Range Complex

Figure 3.4-35: Dwarf Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1



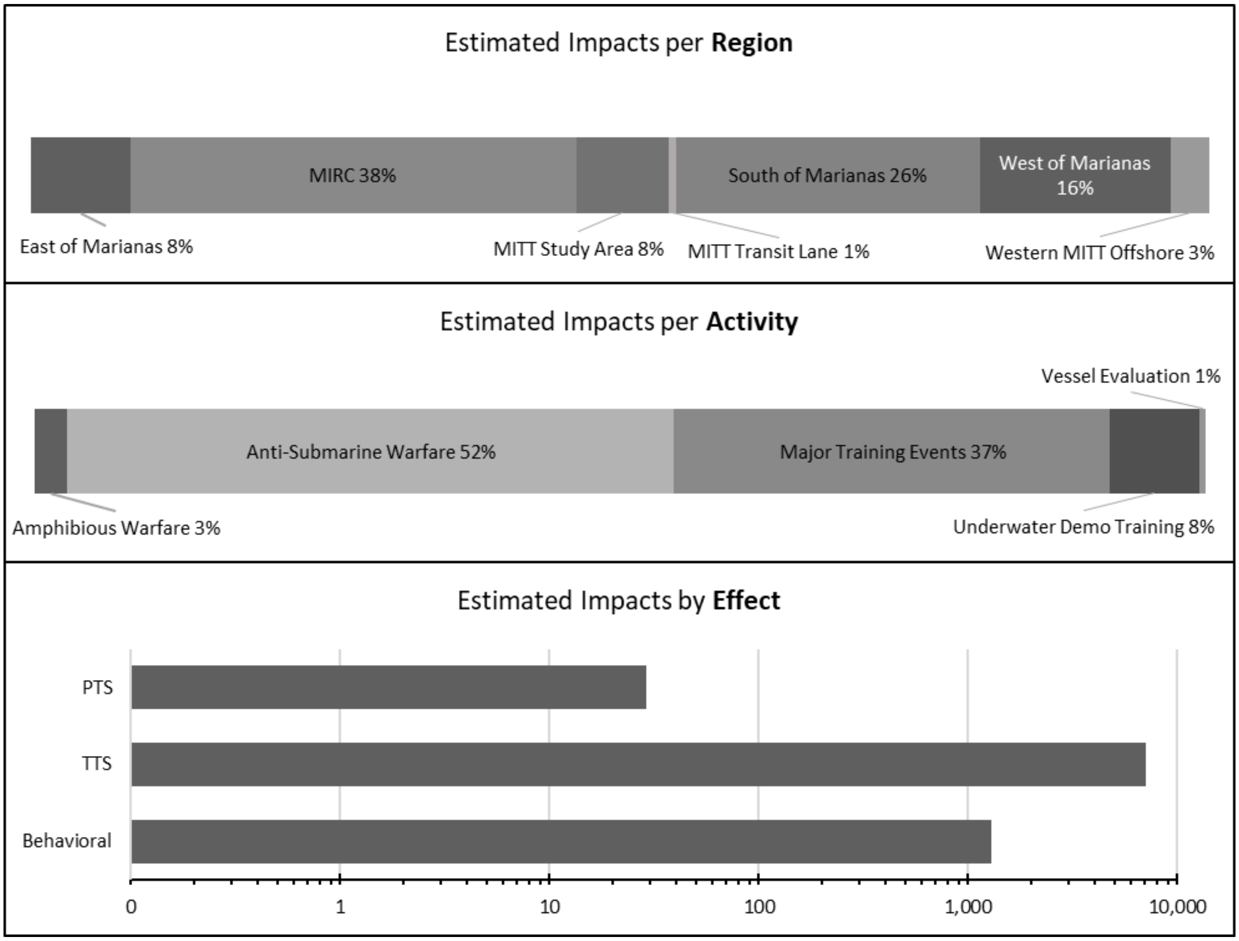
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts.
(2) MIRC = Mariana Islands Range Complex

Figure 3.4-36: Pygmy Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

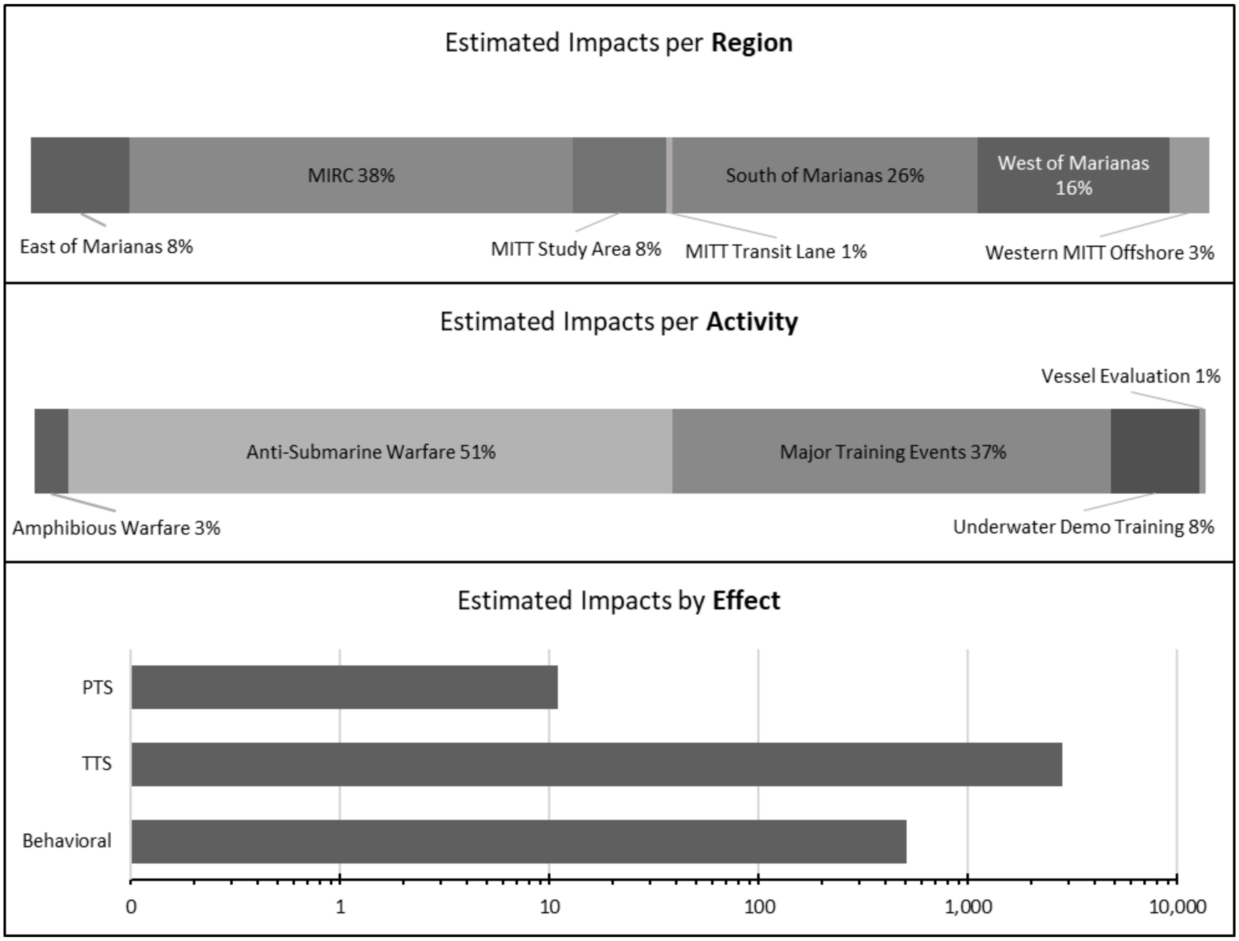
Kogia whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS under Alternative 2. See Figure 3.4-37 and Figure 3.4-38 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Kogia whales (i.e., dwarf and pygmy sperm whales) incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts.
(2) MIRC = Mariana Islands Range Complex

Figure 3.4-37: Dwarf Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts.
(2) MIRC = Mariana Islands Range Complex

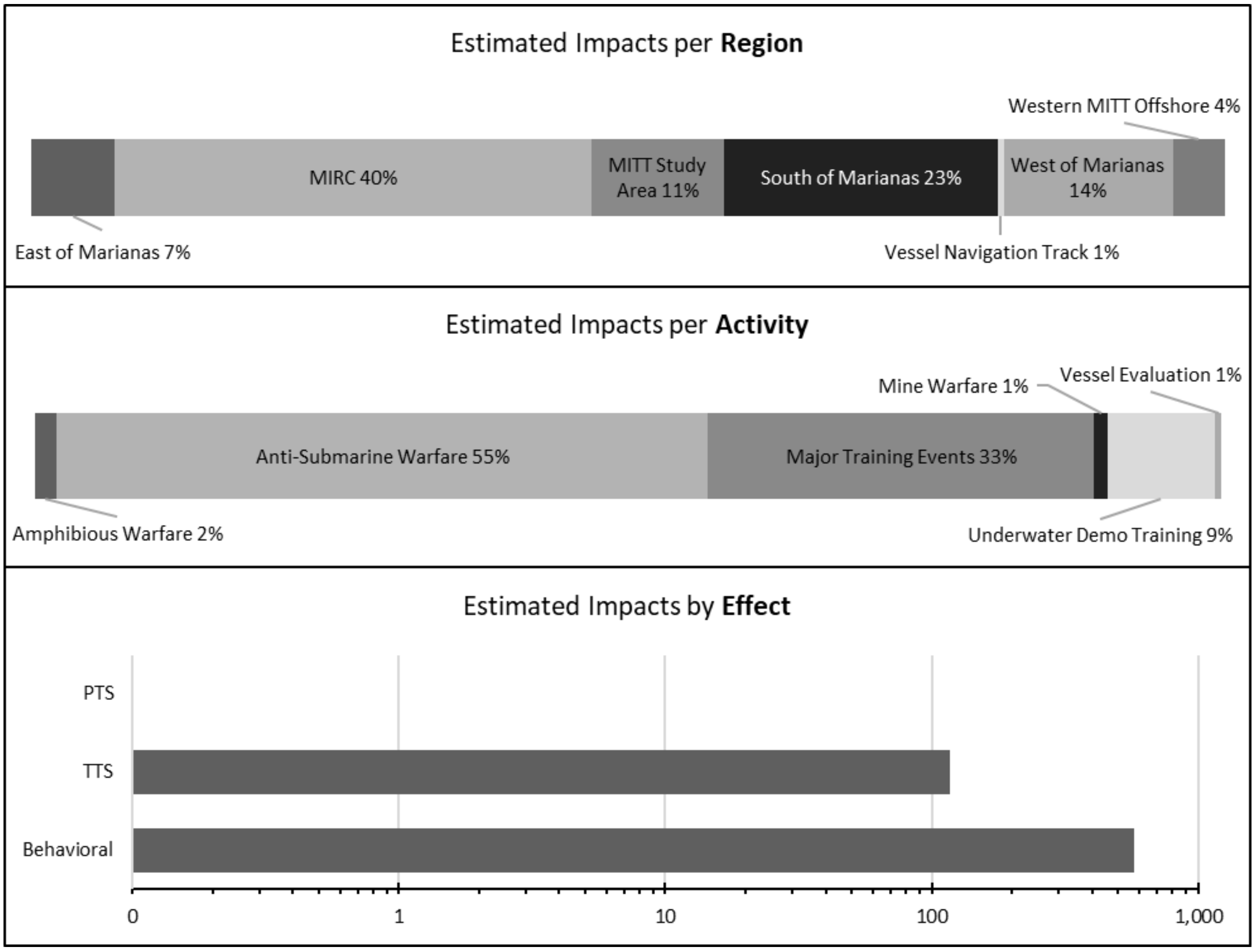
Figure 3.4-38: Pygmy Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

False Killer Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

False killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-39 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of false killer whales incidental to those activities.



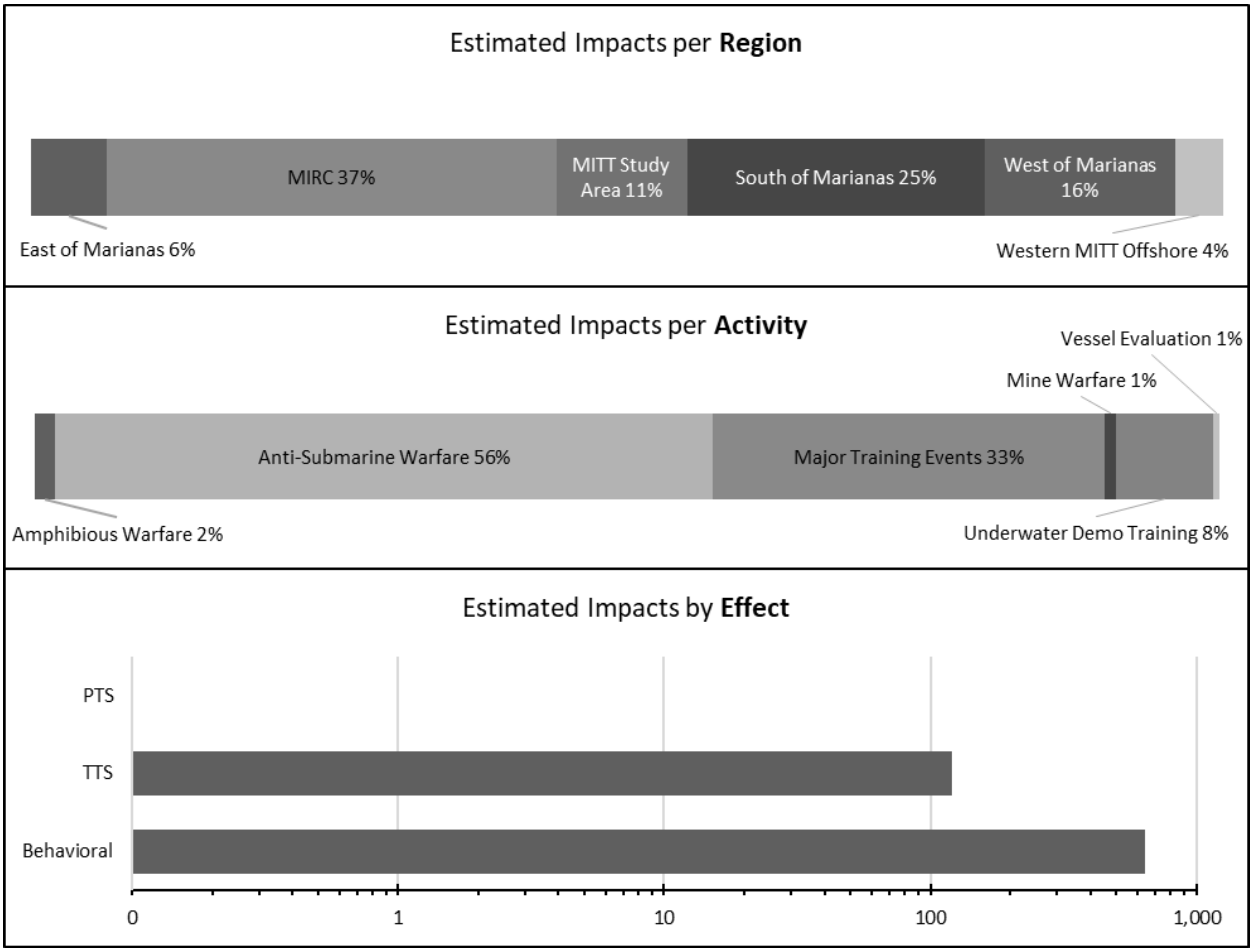
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-39: False Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

False killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-40 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of false killer whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

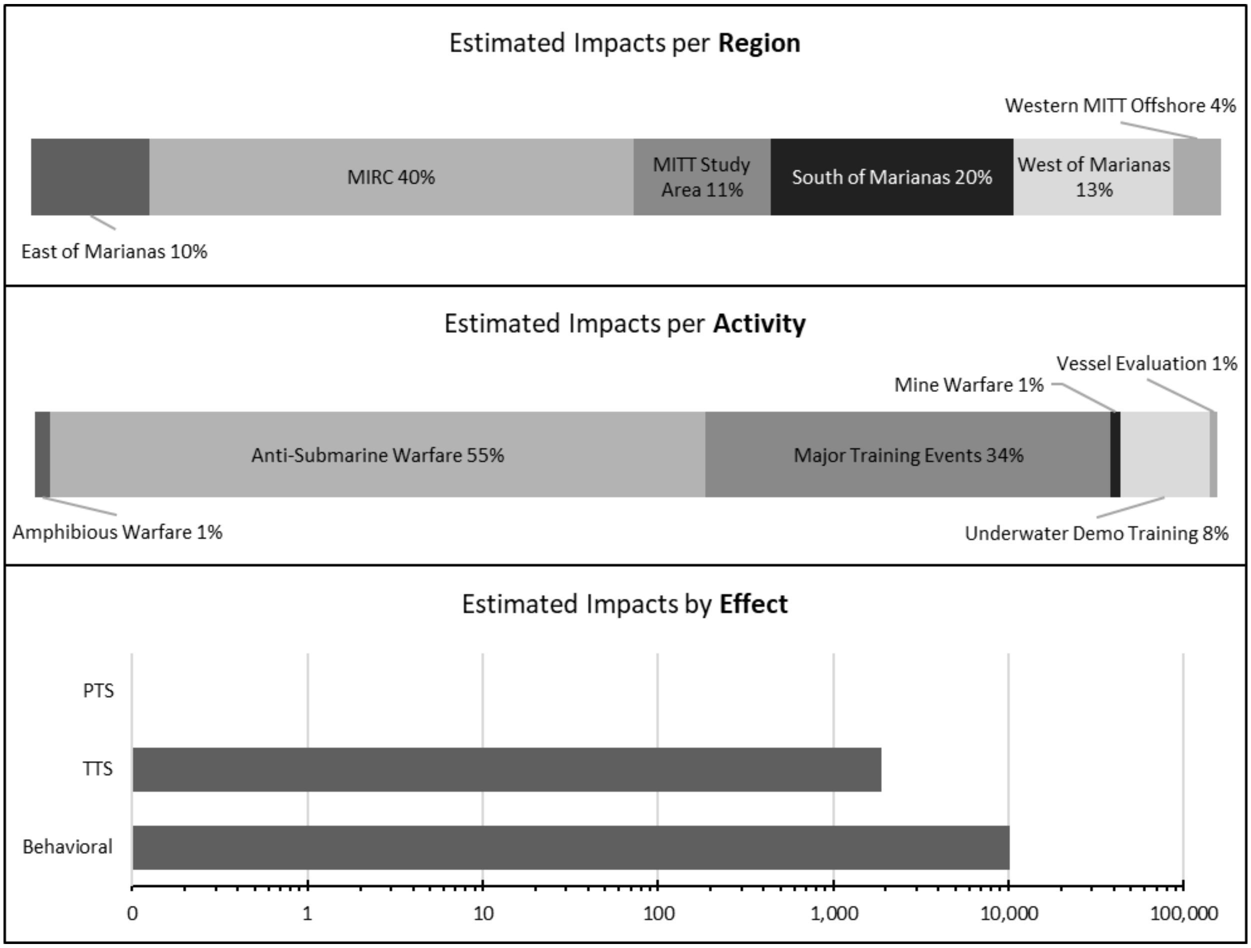
Figure 3.4-40: False Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Fraser's Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Fraser's dolphin may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-41 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Fraser's dolphin incidental to those activities.



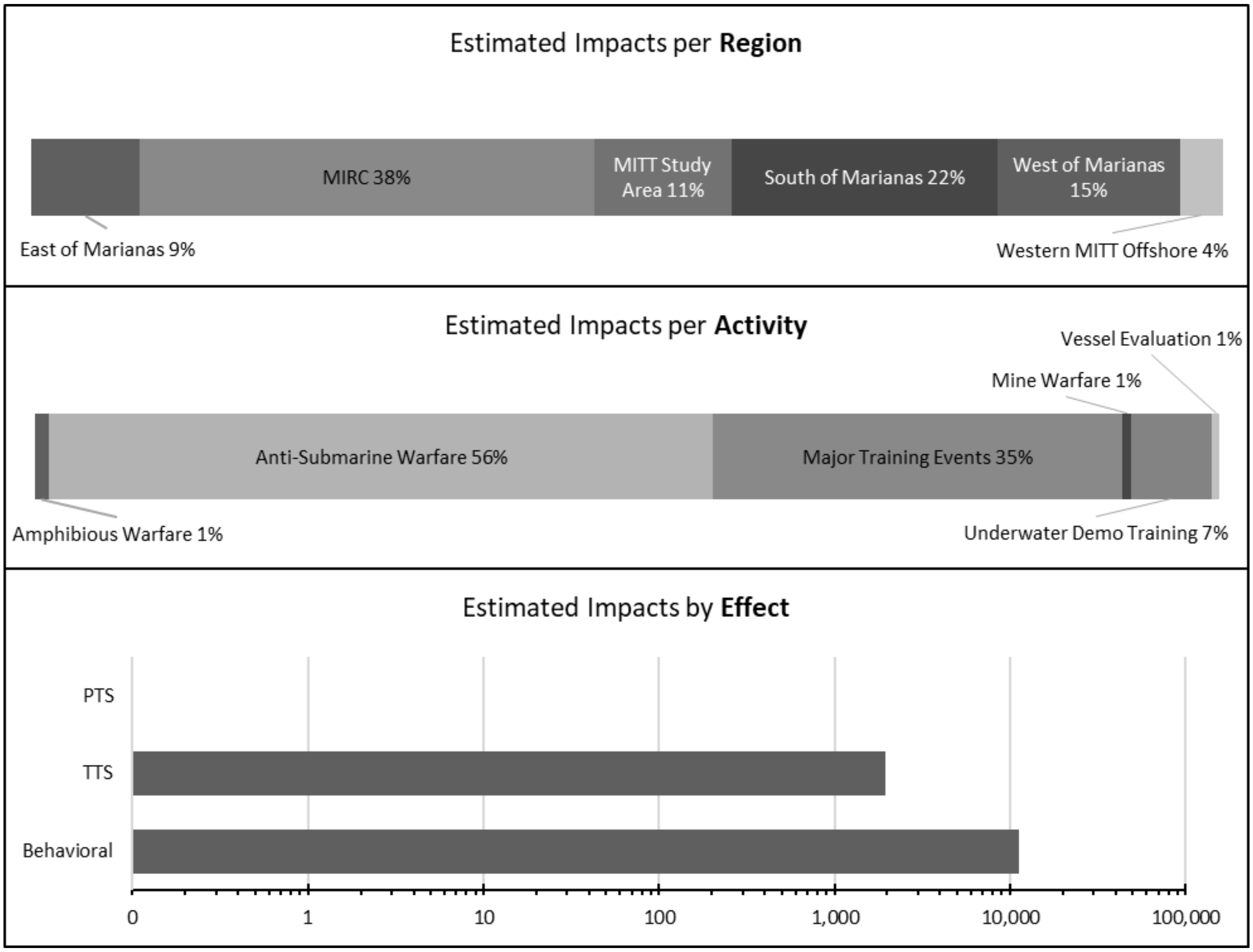
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-41: Fraser's Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Fraser's dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-42 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Fraser's dolphin incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

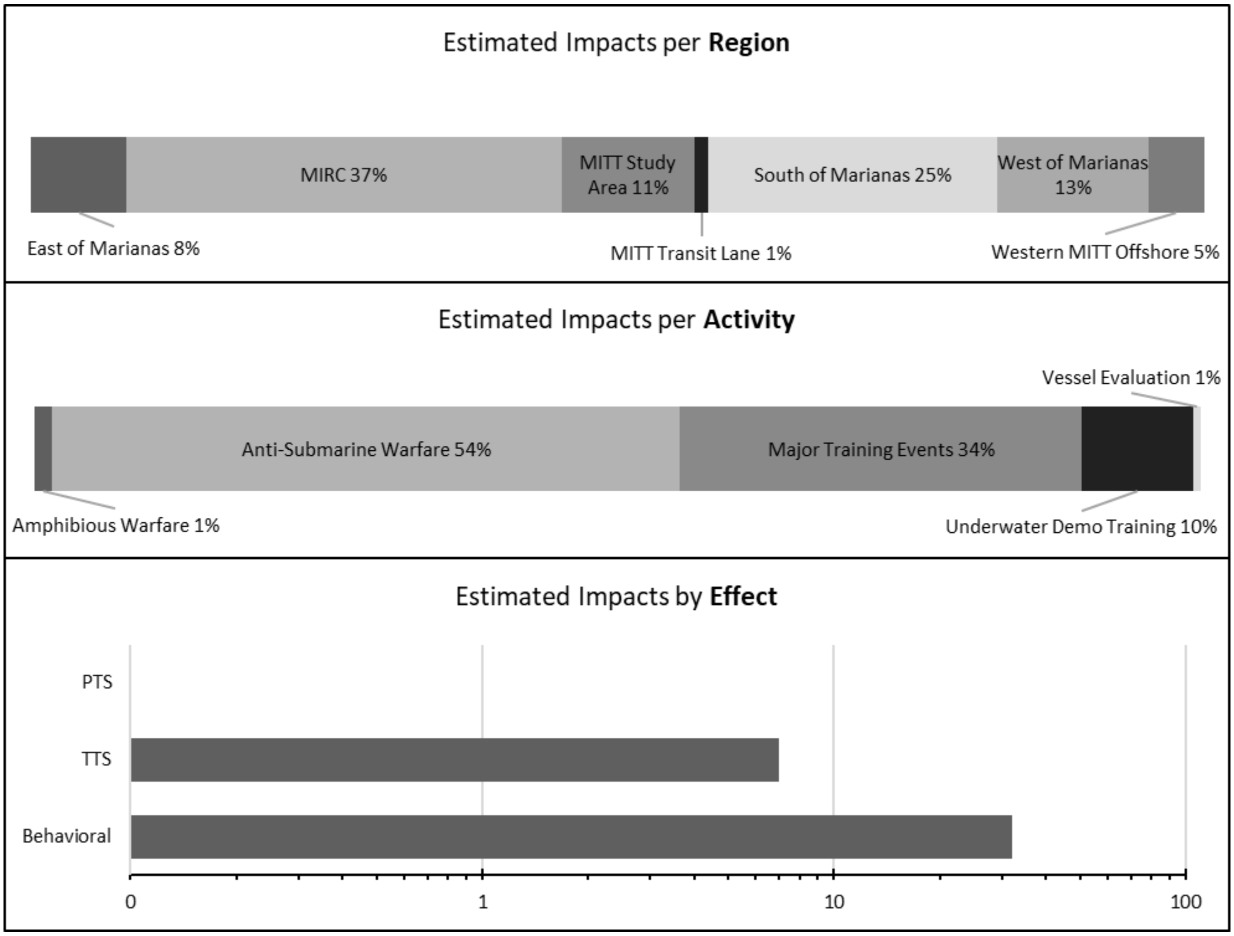
Figure 3.4-42: Fraser's Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Killer Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-43 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of killer whales incidental to those activities.



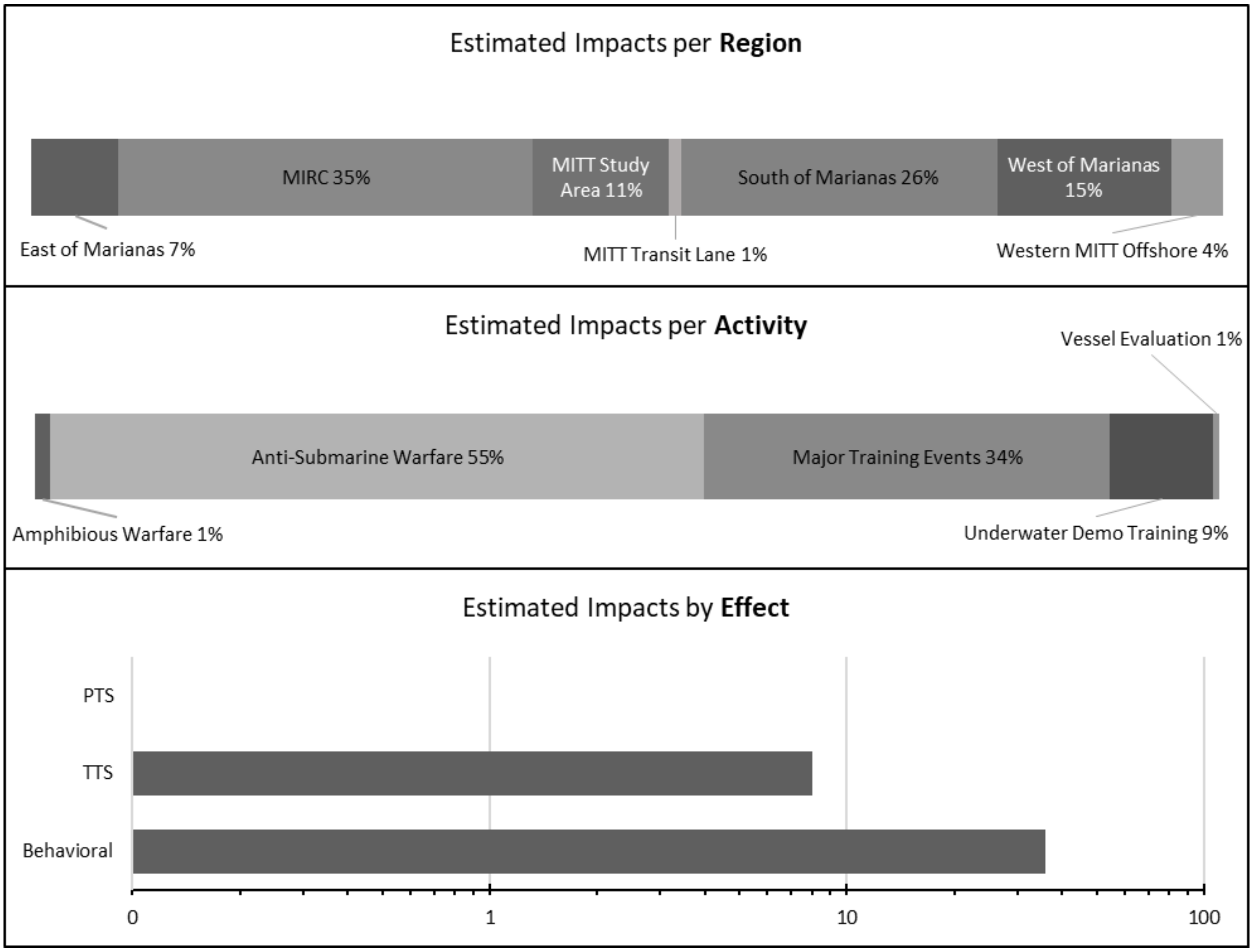
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-43: Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-44 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of killer whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

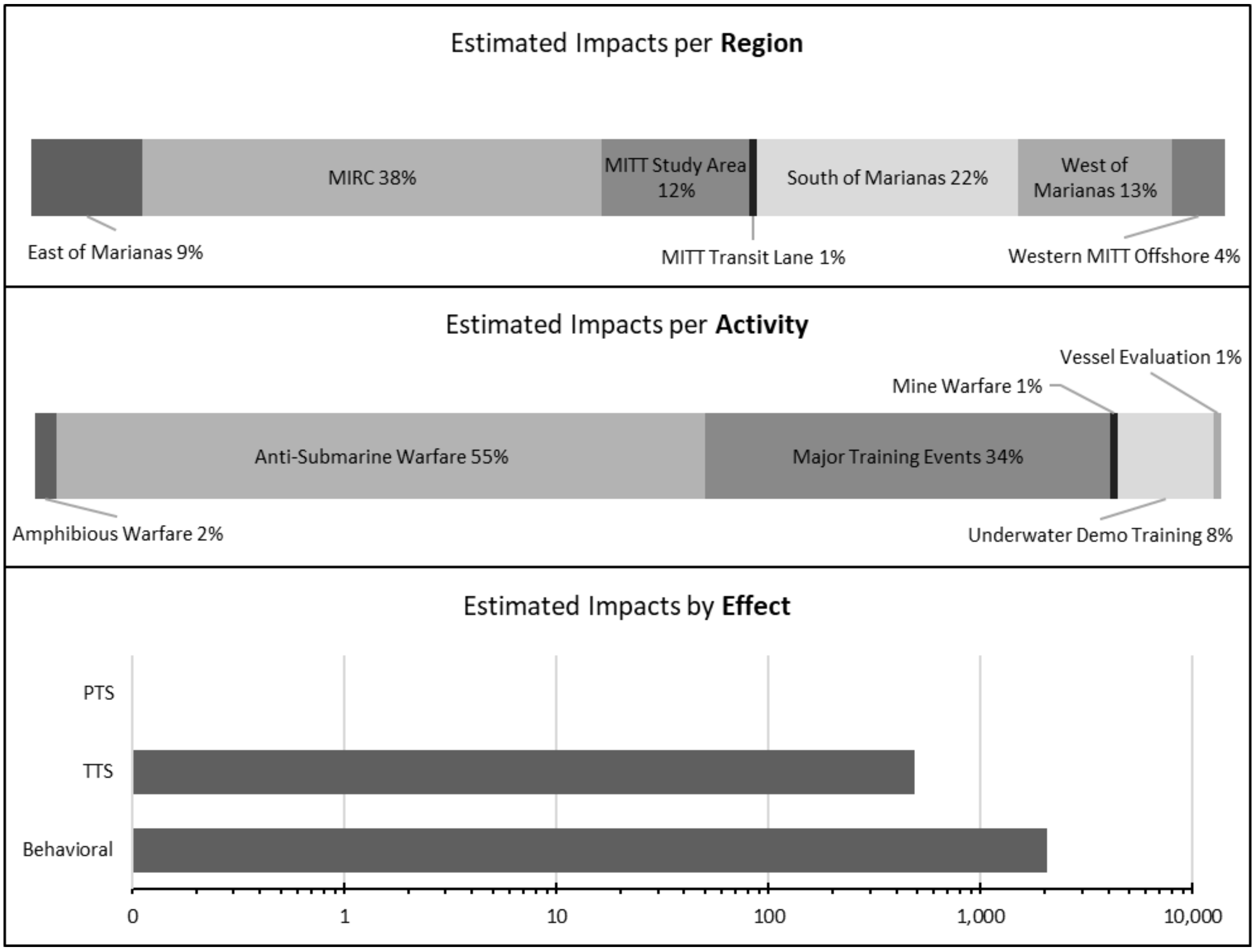
Figure 3.4-44: Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Melon-Headed Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Melon-headed whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-45 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of melon-headed whales incidental to those activities.



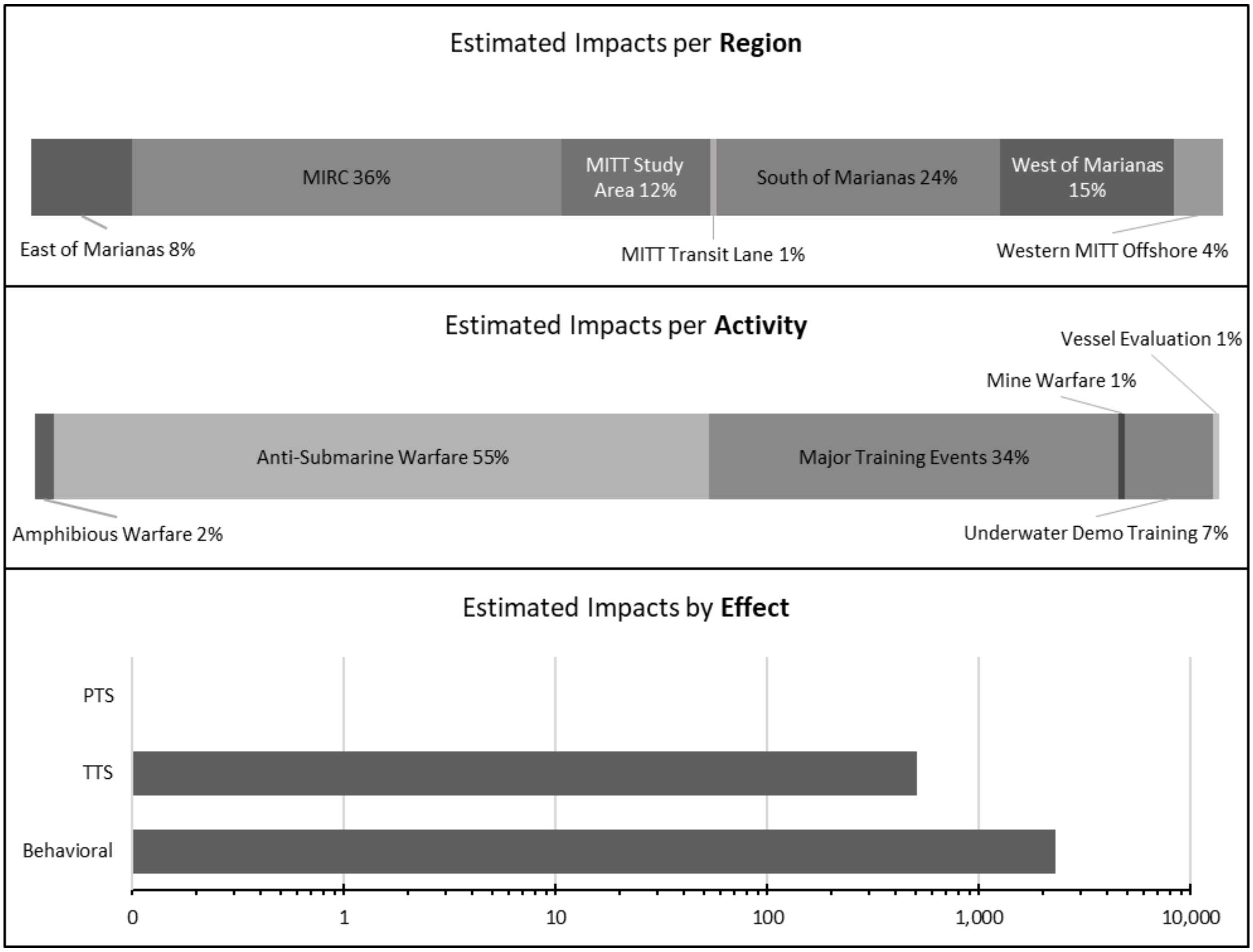
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-45: Melon-Headed Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Melon-headed whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-46 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of melon-headed whales incidental to those activities.



Note: Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

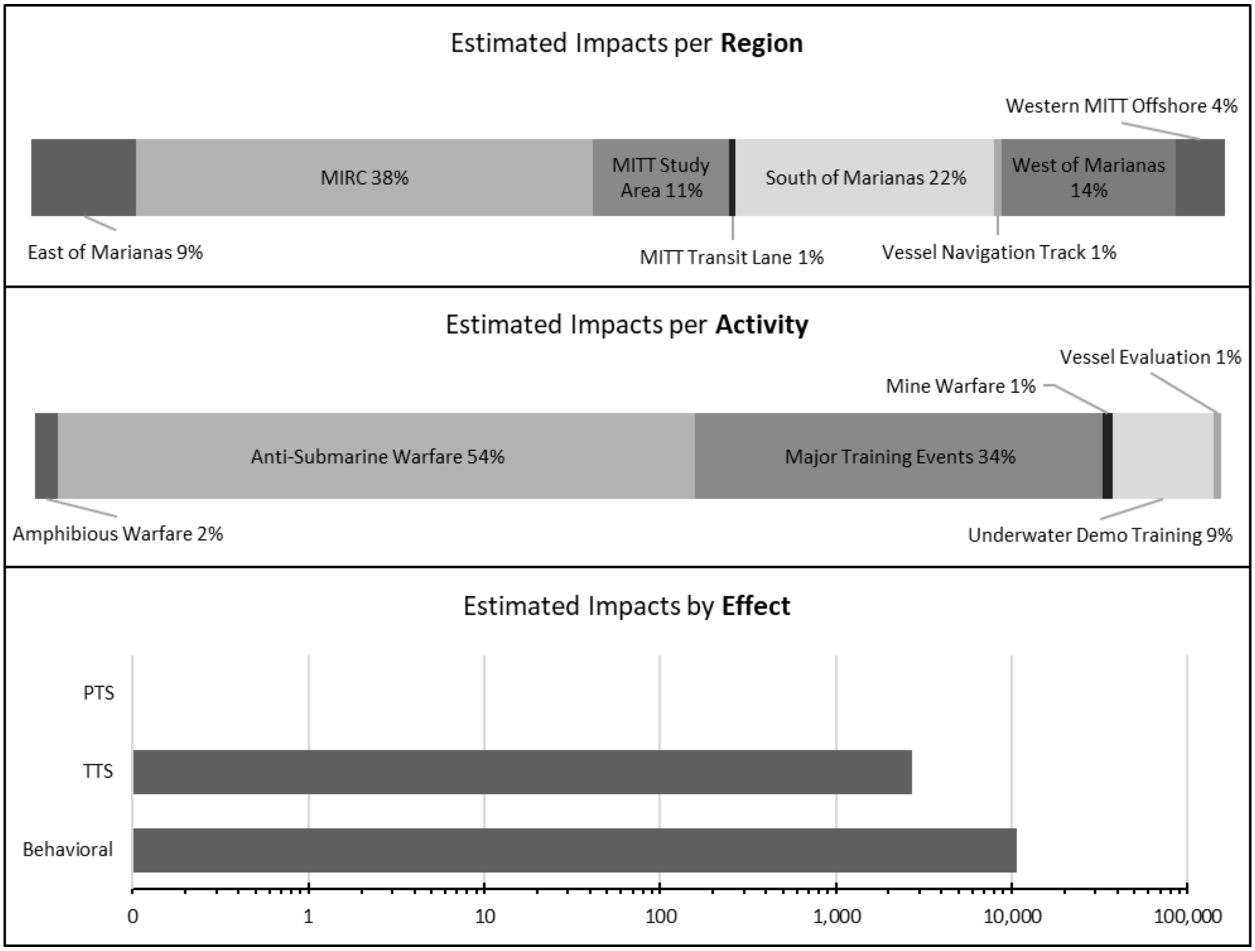
Figure 3.4-46: Melon-Headed Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Pantropical Spotted Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Pantropical spotted dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-47 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of pantropical spotted dolphins incidental to those activities.



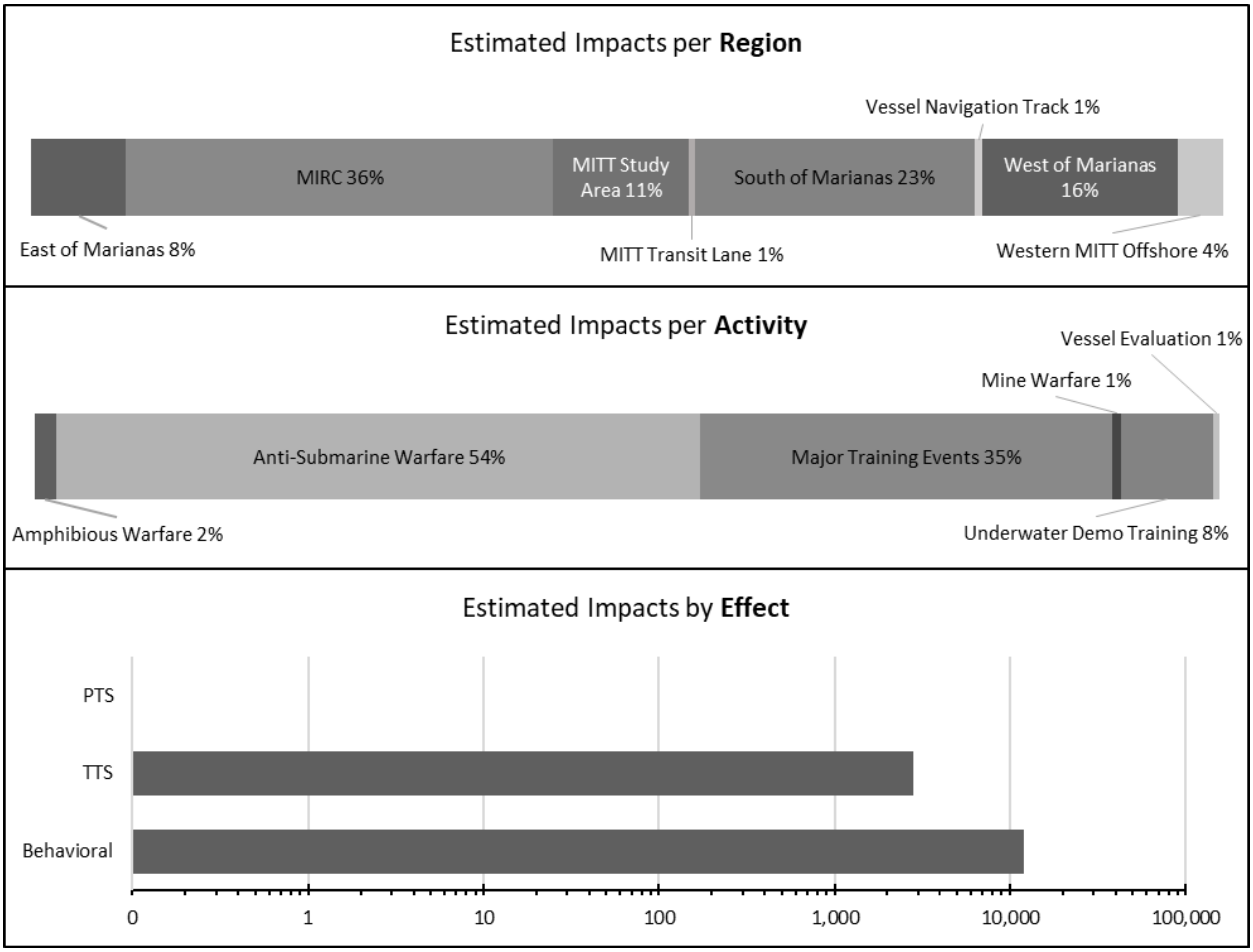
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-47: Pantropical Spotted Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Pantropical spotted dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-48 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of pantropical spotted dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

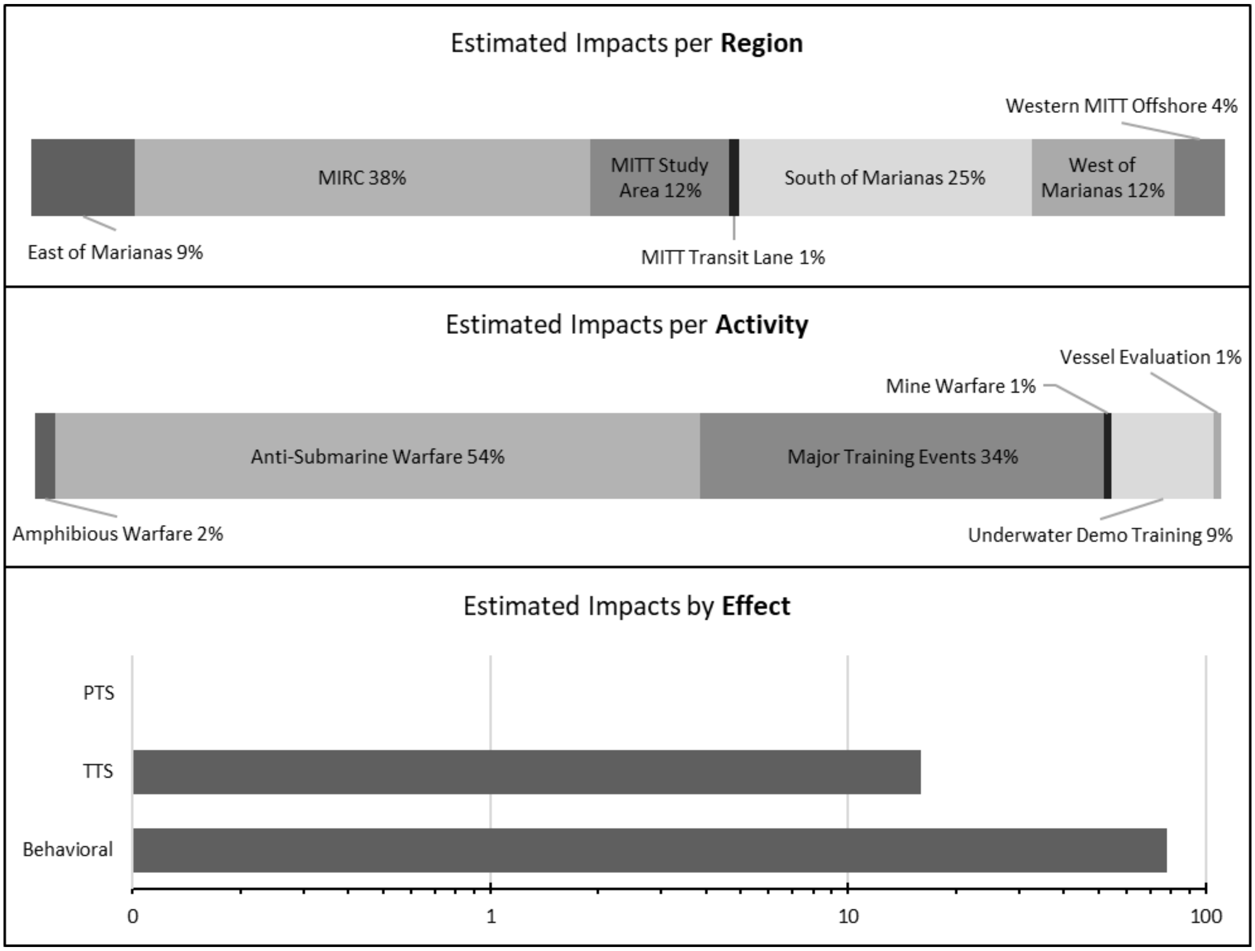
Figure 3.4-48: Pantropical Spotted Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Pygmy Killer Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Pygmy killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-49 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of pygmy killer whales incidental to those activities.



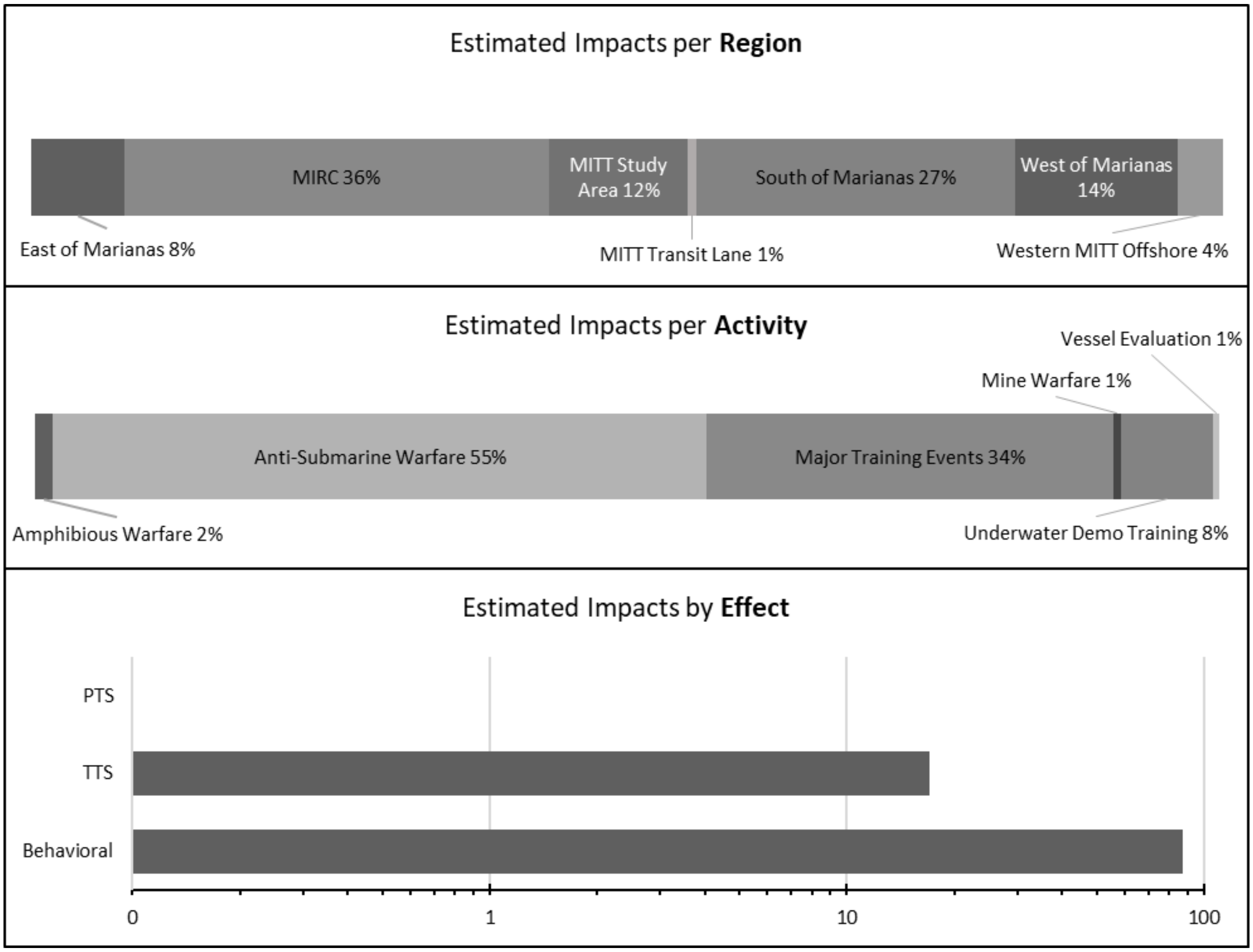
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-49: Pygmy Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Pygmy killer whale may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-50 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of pygmy killer whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

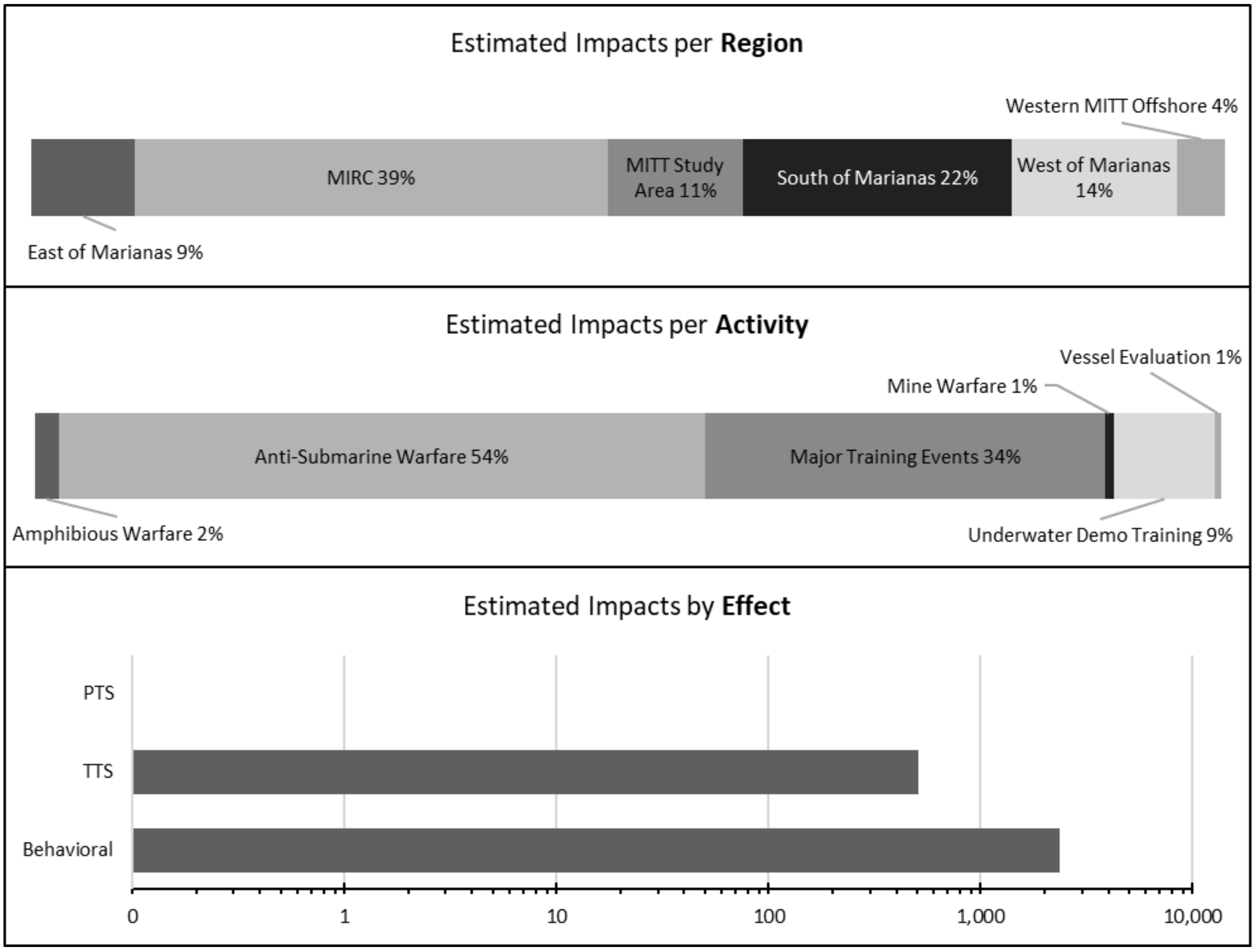
Figure 3.4-50: Pygmy Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Risso's Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Risso's dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-51 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Risso's dolphins incidental to those activities.



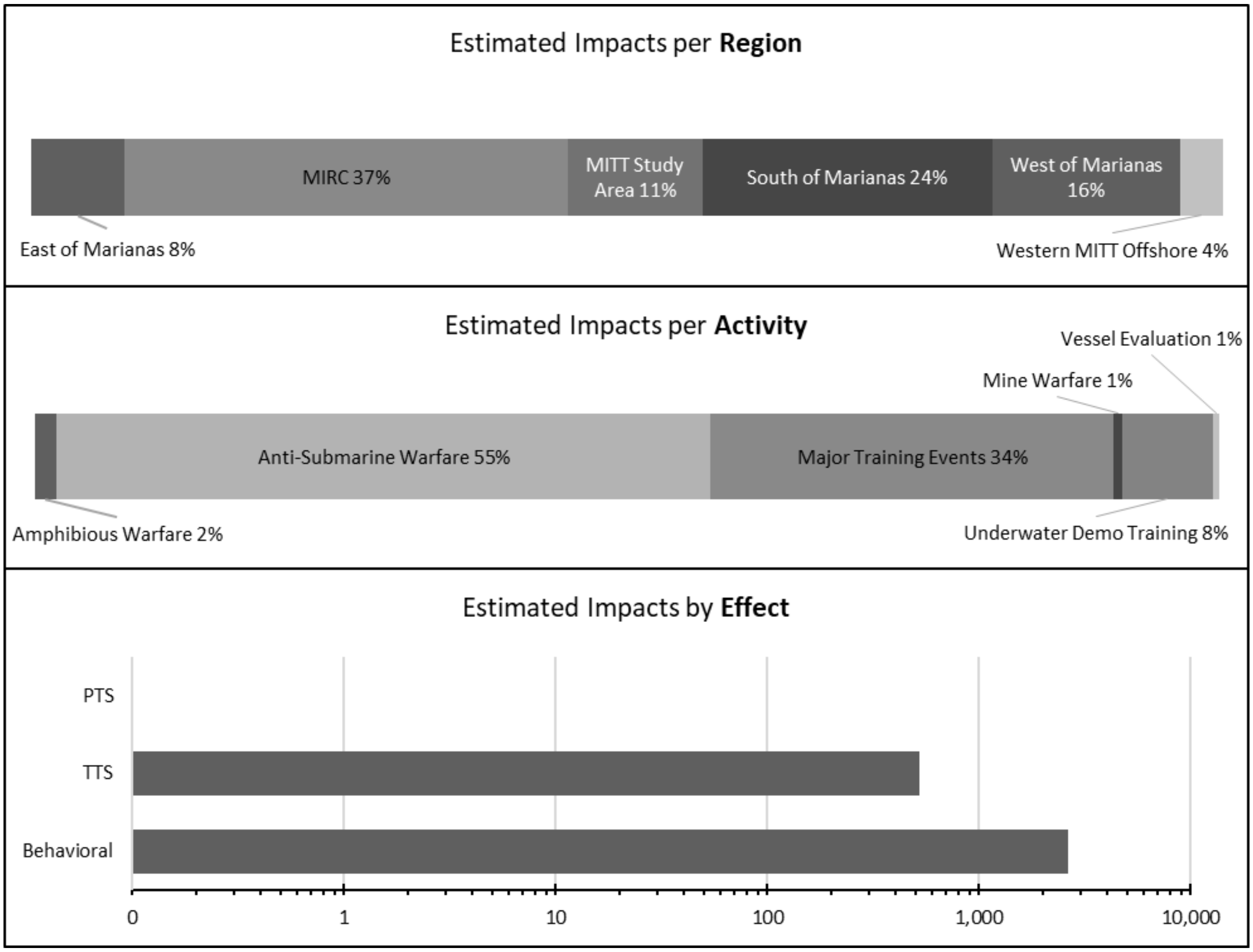
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-51: Risso's Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Risso's dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-52 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2 versus Alternative 1.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Risso's dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

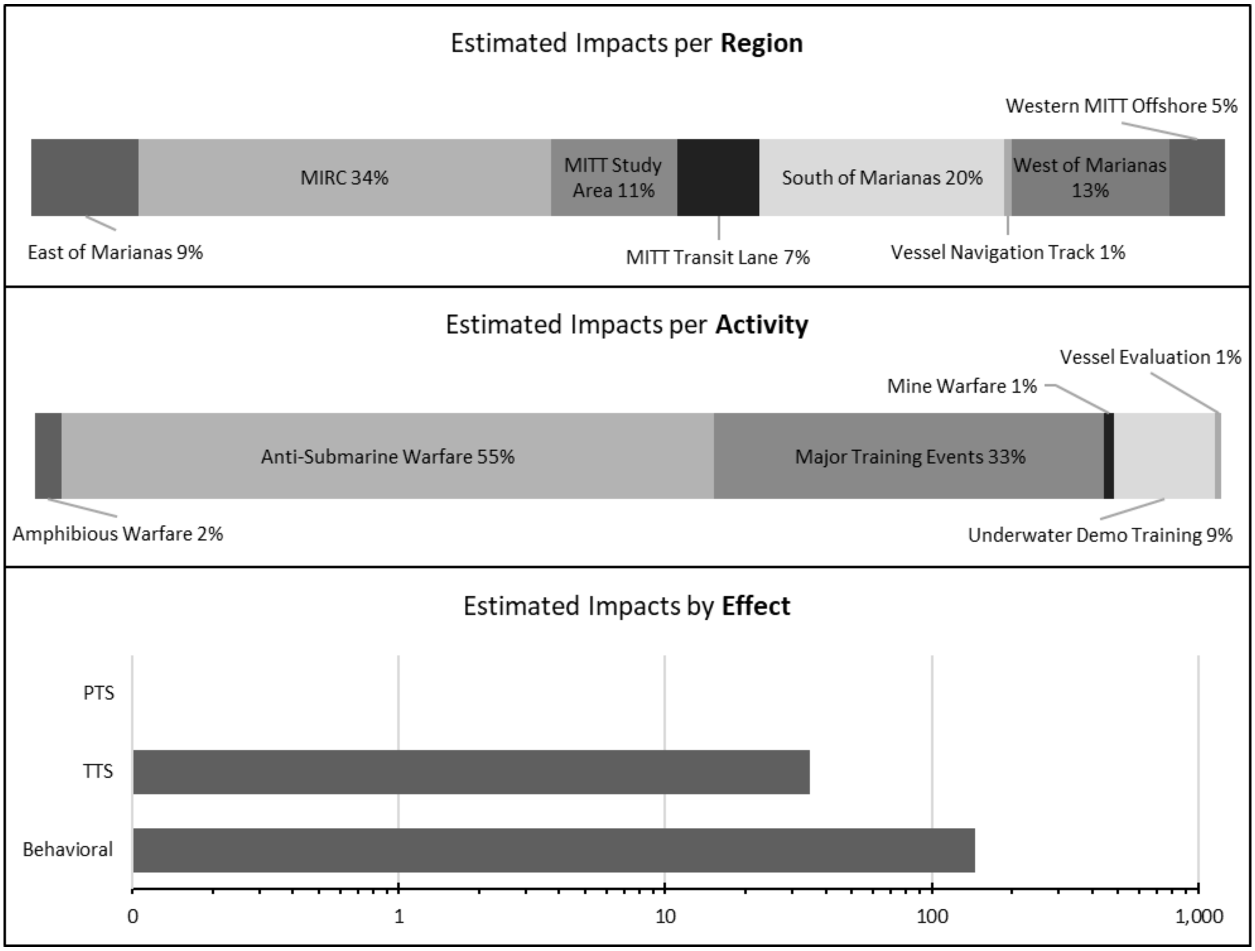
Figure 3.4-52: Risso's Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Rough-Toothed Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Rough-toothed dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-53 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of rough-toothed dolphins incidental to those activities.



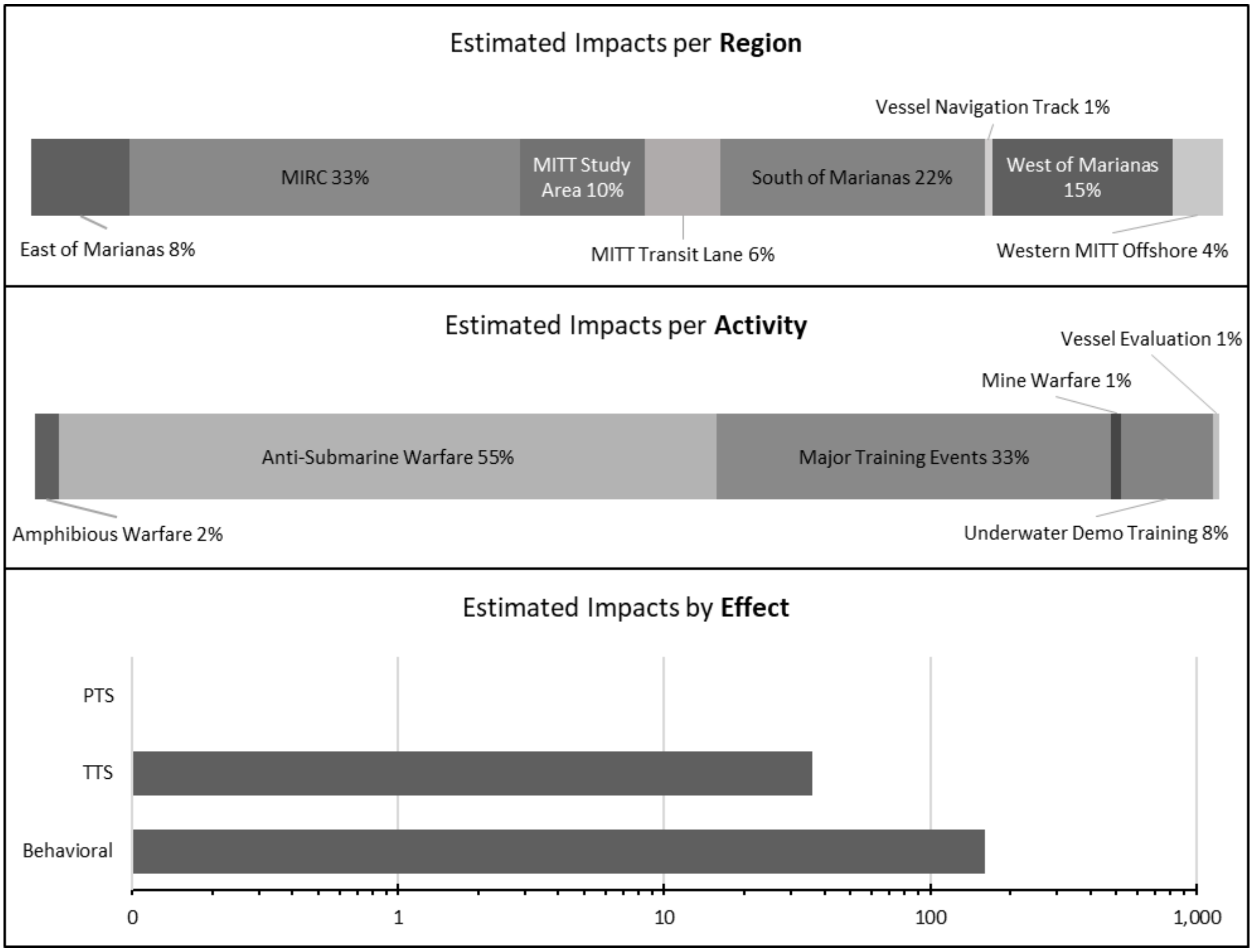
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-53: Rough-Toothed Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Rough-toothed dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-54 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of rough-toothed dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

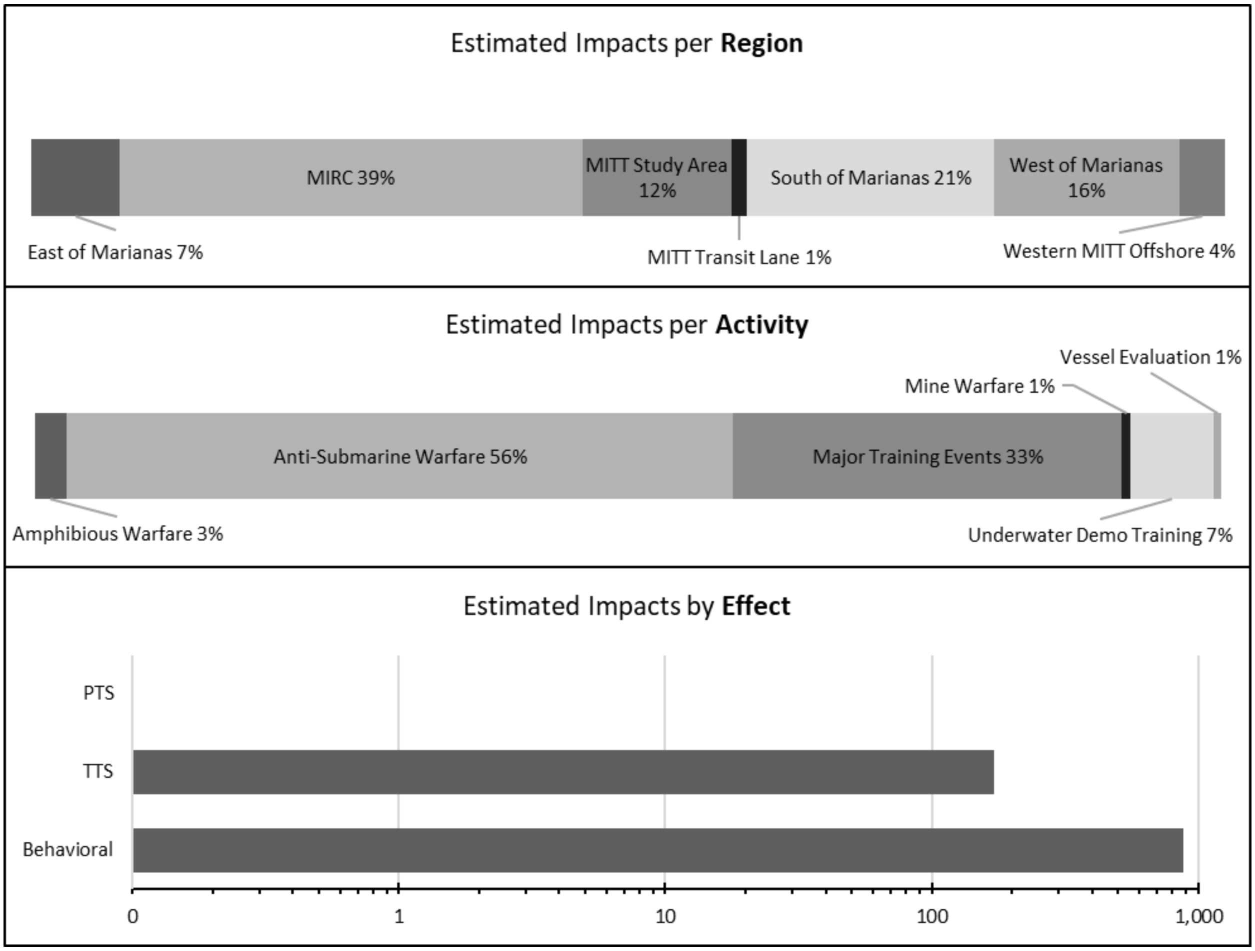
Figure 3.4-54: Rough-Toothed Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Short-Finned Pilot Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Short-finned pilot whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-55 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of short-finned pilot whales incidental to those activities.



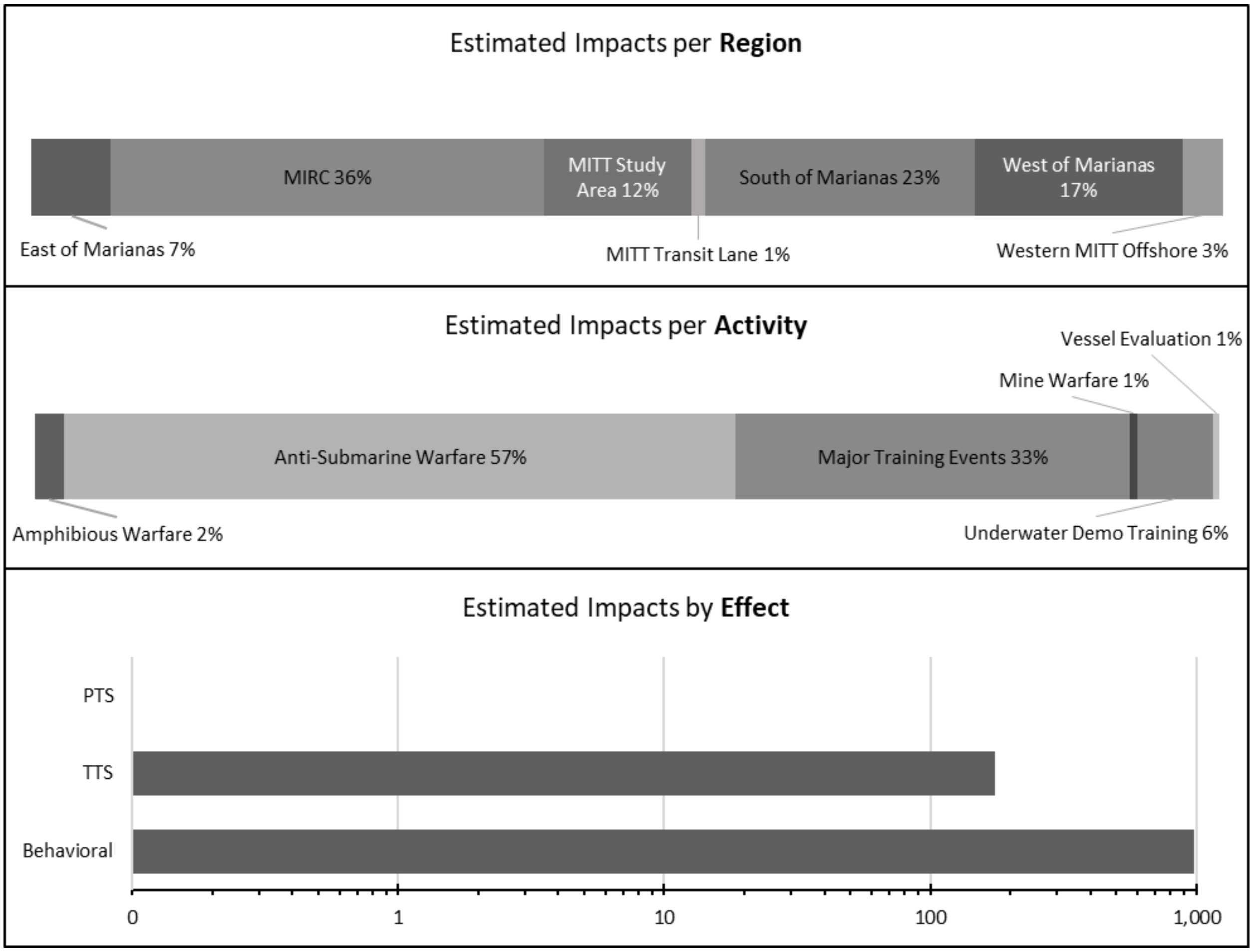
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-55: Short-Finned Pilot Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Short-finned pilot whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-56 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of short-finned pilot whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-56: Short-Finned Pilot Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

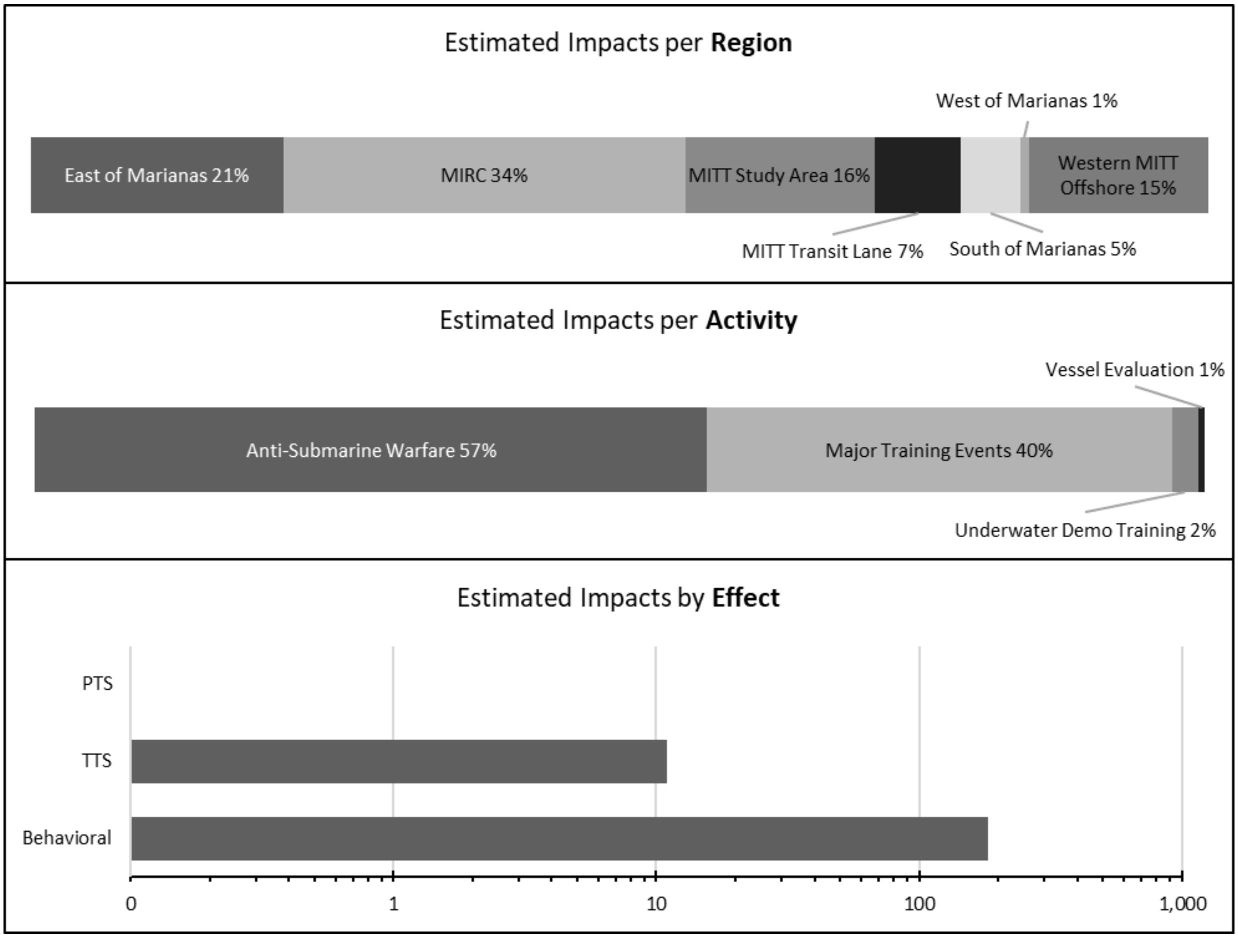
Sperm Whale (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Sperm whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-57 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of sperm whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 may affect ESA-listed sperm whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

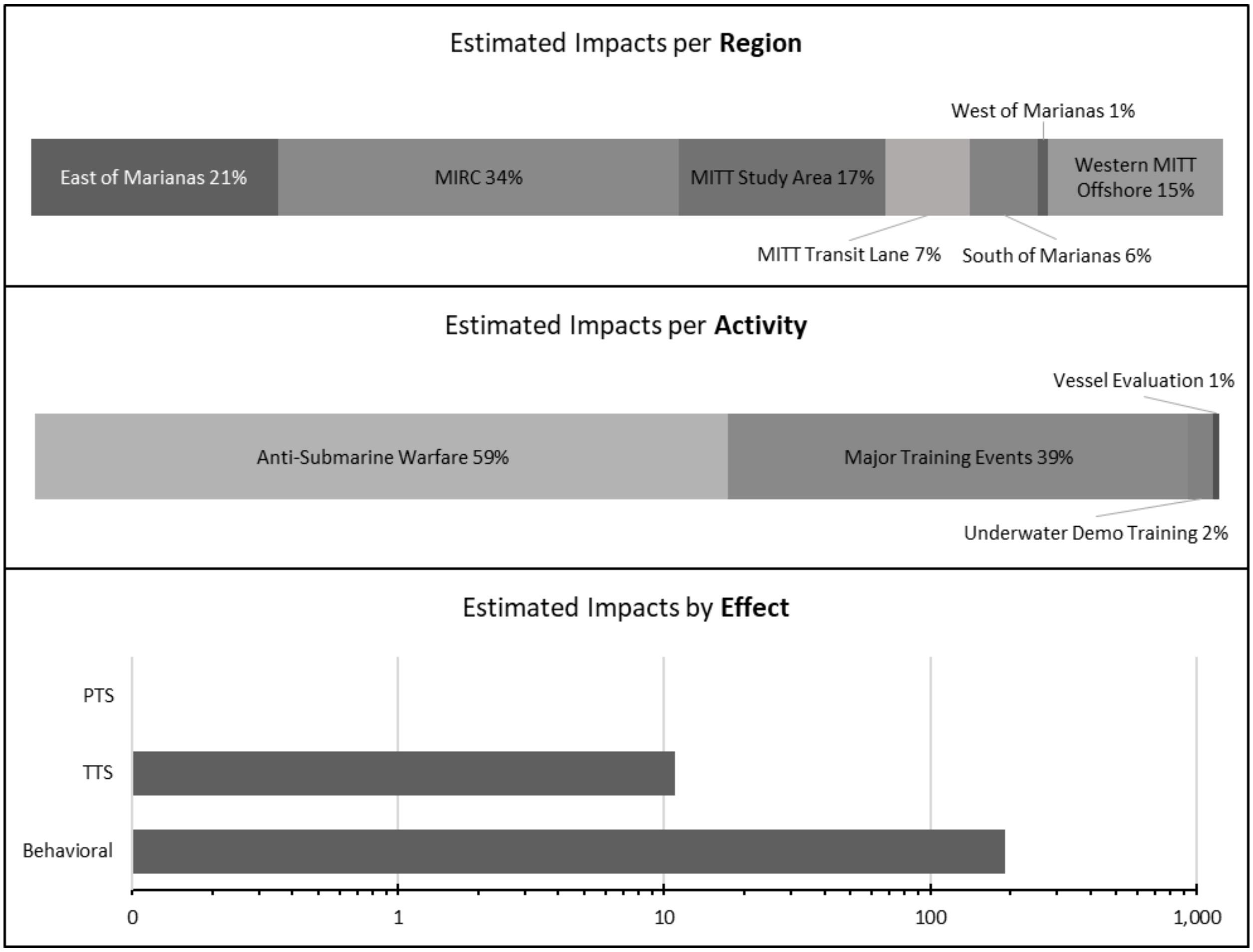
Figure 3.4-57: Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Sperm whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-58 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of sperm whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 may affect ESA-listed sperm whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-58: Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

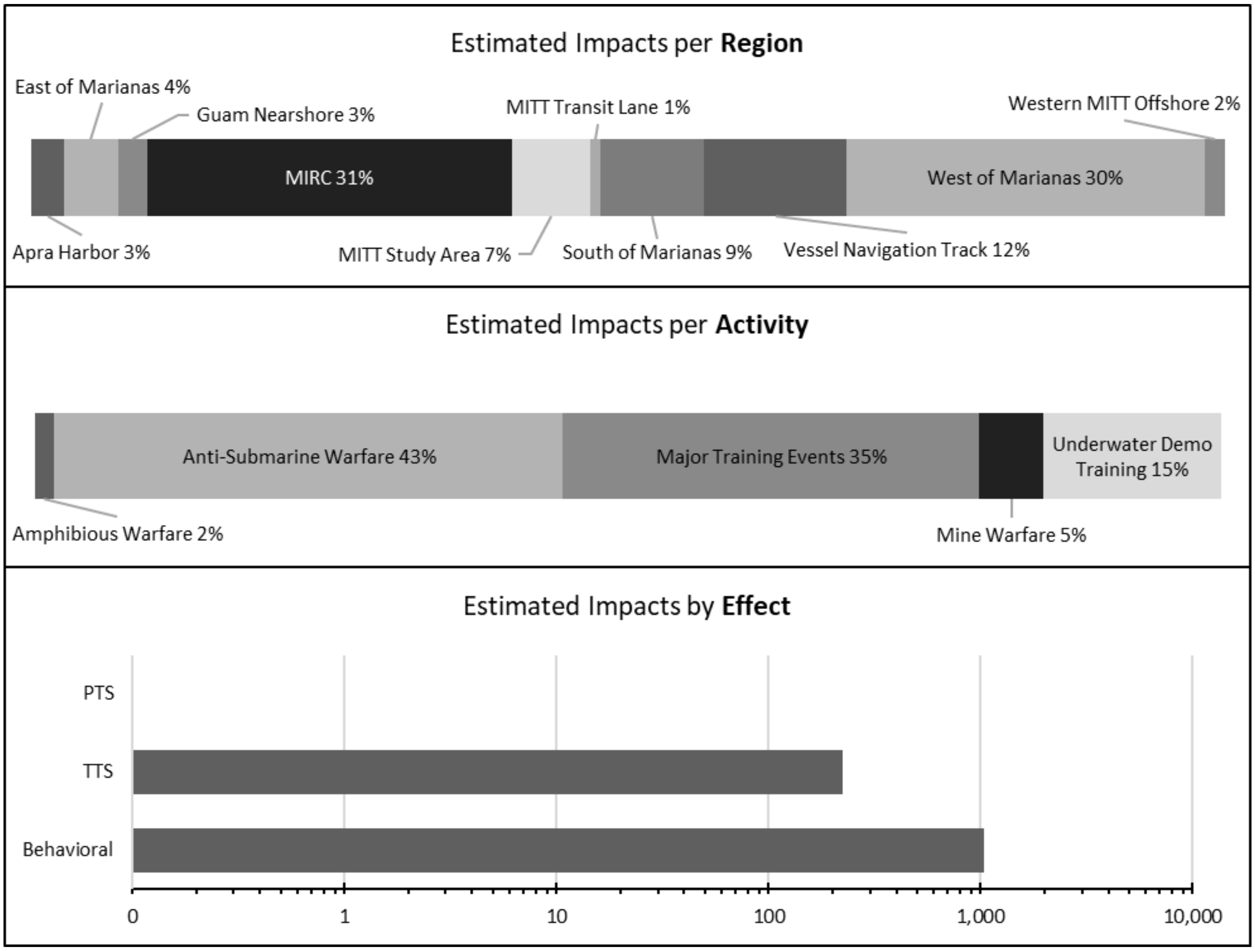
Spinner Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Spinner dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-59 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact

Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of spinner dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

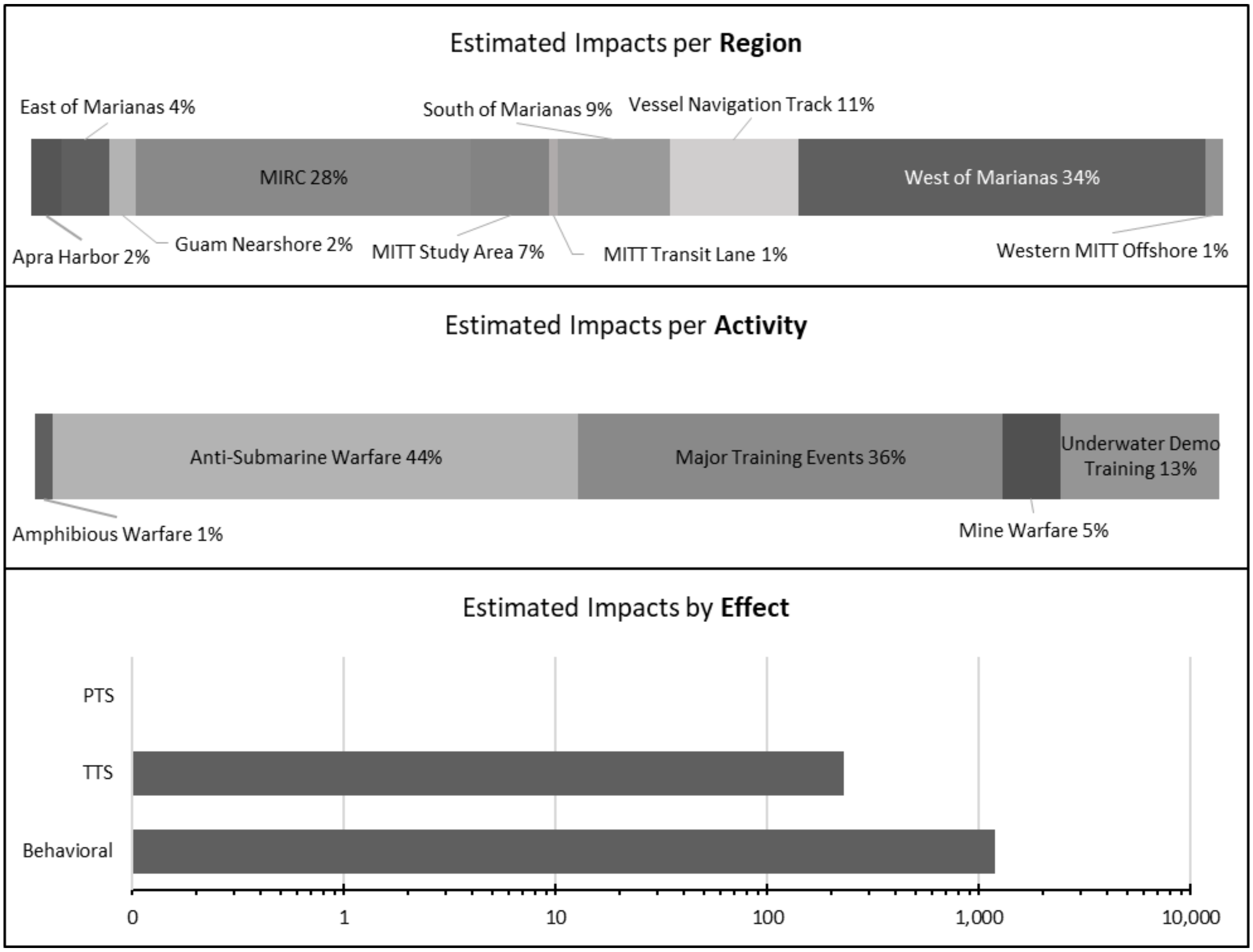
Figure 3.4-59: Spinner Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Spinner dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-60 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact

Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of spinner dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-60: Spinner Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

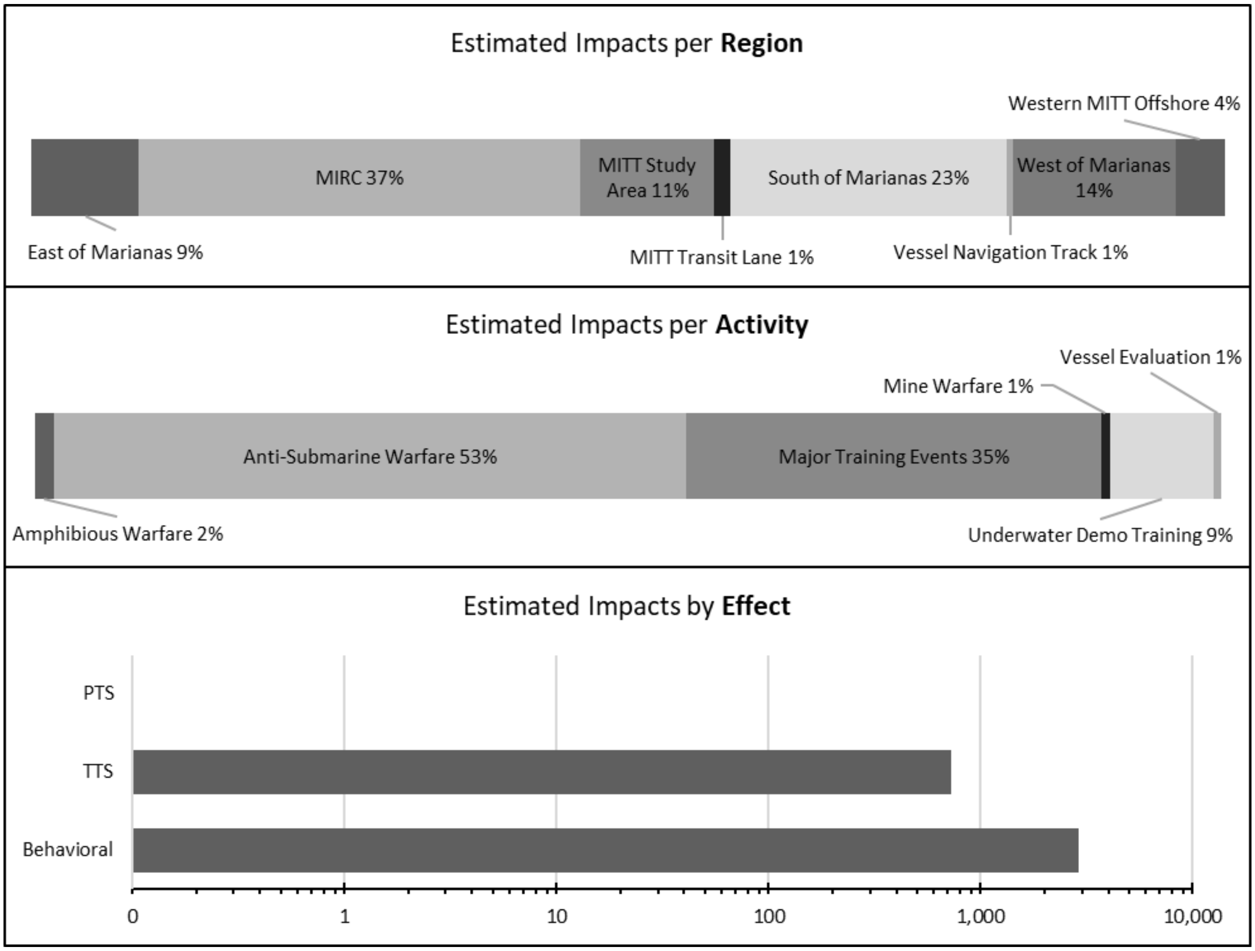
Striped Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Striped dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1. See Figure 3.4-61 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact

Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of striped dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

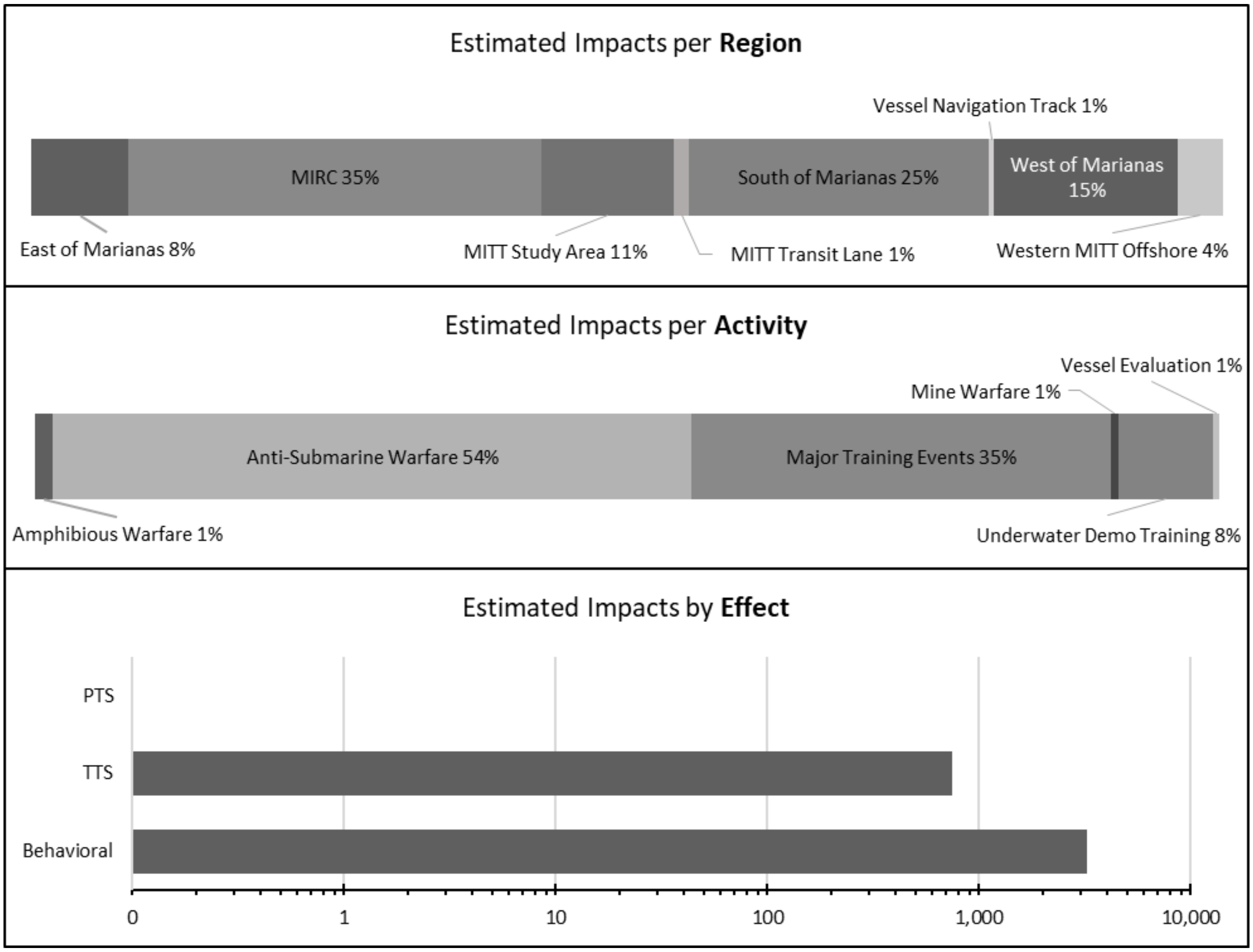
Figure 3.4-61: Striped Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Striped dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2. See Figure 3.4-62 below or Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) for tabular results. Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact

Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of striped dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-62: Striped Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

3.4.2.1.2.4 Impacts from Sonar and Other Transducers Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors from the use of sonar and other transducers, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that use sonar and other transducers within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from sonar and other transducers on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.1.3 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 are in Section 3.0.4.1.2 (Vessel Noise). Vessel movements involve transits to and from ports to various locations within the Study Area, including commercial ship traffic as well as recreational vessels in addition to U.S. Navy vessels. 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). Section 3.4.2.1.1 (Background) summarizes and synthesizes available information on behavioral reactions, masking, and physiological stress due to noise exposure, including vessel noise (Section 3.4.2.1.1.2, Hearing Loss; Section 3.4.2.1.1.3, Physiological Stress; Section 3.4.2.1.1.4, Masking; and Section 3.4.2.1.1.5, Behavioral Reactions).

Activities may vary slightly from those previously analyzed in the 2015 MITT Final EIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Table 2.5-1 and Table 2.5-2 for proposed activities under Alternative 1 and 2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS. The Navy will implement mitigation measures for vessel movement to avoid the potential for marine mammal vessel strikes, as discussed in Section 5.3.4.1 (Vessel Movement). The mitigation for vessel movement (i.e., maneuvering to maintain a specified distance from a marine mammal) will also help the Navy avoid or reduce potential impacts from vessel noise on marine mammals.

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors (i.e., vessel noise) from the use of vessels, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that produce vessel noise within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from vessel noise on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

Pursuant to the MMPA, vessel noise during training and testing activities as described under Alternative 1 and Alternative 2 would not result in the unintentional taking of marine mammals.

Pursuant to the ESA, vessel noise during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed marine mammals.

3.4.2.1.4 Impacts from Aircraft Noise

Marine mammals may be exposed to aircraft-generated noise throughout the Study Area. Fixed- and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area. Tilt-rotor impacts would be similar to fixed-wing or helicopter impacts depending which mode the aircraft is in. Most of these sounds would be concentrated around airbases and fixed ranges within the range complex. Aircraft produce extensive airborne noise from either turbofan or turbojet engines. An infrequent type of aircraft noise is the sonic boom, produced when the aircraft exceeds the speed of sound. Rotary-wing aircraft produce low-frequency sound and vibration (Pepper et al., 2003). Section 3.4.2.1.1 (Background) summarizes and synthesizes available information on behavioral reactions, masking, and physiological stress due to noise exposure, including aircraft noise (Section 3.4.2.1.1.2, Hearing Loss; Section 3.4.2.1.1.3, Physiological Stress; Section 3.4.2.1.1.4, Masking; and Section 3.4.2.1.1.5, Behavioral Reactions).

A detailed description of aircraft noise as a stressor is in Section 3.0.4.1.3 (Aircraft Noise). Activities may vary slightly from those previously analyzed in the 2015 MITT Final EIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Table 2.5-1 and Table 2.5-2 for proposed training and testing activities under Alternative 1 and 2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors (i.e., aircraft noise) from the use of aircraft, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that produce aircraft noise within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from aircraft noise on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

Pursuant to the MMPA, aircraft noise during training and testing activities as described under Alternative 1 and Alternative 2 would not result in the unintentional taking of marine mammals.

Pursuant to the ESA, aircraft noise during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed marine mammals.

3.4.2.1.5 Impacts from Weapon Noise

Marine mammals may be exposed to sounds caused by the firing of weapons, objects in flight, and inert impact of non-explosive munitions on the water's surface, which are described in Section 3.0.4.1.4 (Weapon Noise). In general, these are impulsive sounds generated in close vicinity to or at the water surface, with the exception of items that are launched underwater. The firing of a weapon may have several components of associated noise. Firing of guns could include sound generated in air by firing a gun (muzzle blast) and a crack sound due to a low amplitude shock wave generated by a supersonic projectile flying through the air. Most in-air sound would be reflected at the air-water interface.

Underwater sounds would be strongest just below the surface and directly under the firing point. Any sound that enters the water only does so within a narrow cone below the firing point or path of the projectile. Vibration from the blast propagating through a ship’s hull, the sound generated by the impact of an object with the water surface, and the sound generated by launching an object underwater are other sources of impulsive sound in the water. 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.

Section 3.4.2.1.1 (Background) summarizes and synthesizes available information on behavioral reactions, masking, and physiological stress due to noise exposure, including aircraft noise (Section

3.4.2.1.1.2, Hearing Loss; Section 3.4.2.1.1.3, Physiological Stress; Section 3.4.2.1.1.4, Masking; and Section 3.4.2.1.1.5, Behavioral Reactions).

Activities may vary slightly from those previously analyzed in the 2015 MITT Final EIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Table 2.5-1 and Table 2.5-2 for proposed training and testing activities under Alternative 1 and 2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS. The Navy will implement mitigation measures to avoid or reduce potential impacts from weapon noise during large-caliber gunnery activities, as discussed in Section 5.3.2.2 (Weapons Firing Noise).

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur; however, weapon noise would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Under the No Action Alternative, discontinuing training and testing activities that produce weapon noise within the marine environment where training and testing activities have historically been conducted would reduce the potential for impacts from weapon noise on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

Pursuant to the MMPA, weapon noise during training and testing activities as described under Alternative 1 and Alternative 2 would not result in the unintentional taking of marine mammals.

Pursuant to the ESA, weapon noise during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed marine mammals.

3.4.2.2 Explosive Stressors

Assessing whether an explosive detonation may disturb or injure a marine mammal involves understanding the characteristics of the explosive sources, the marine mammals that may be present near the sources, the physiological effects of a close explosive exposure, and the effects of impulsive sound on marine mammal hearing and behavior. Many other factors besides the received level or pressure wave of an explosion, such as the animal's physical condition and size, prior experience with the explosive sound, and proximity to the explosion, may influence physiological effects and behavioral reactions.

The ways in which an explosive exposure could result in immediate effects or lead to long-term consequences for an animal are explained in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). The following background section discusses what is currently known about explosive effects to marine mammals.

Due to new acoustic impact criteria, marine mammal densities, and revisions to the acoustics effects model, the analysis provided in Section 3.4.2.2.2 (Impacts from Explosive Stressors) of this SEIS/OEIS supplants the 2015 MITT Final EIS/OEIS for marine mammals and changes estimated impacts for some species since the 2015 MITT Final EIS/OEIS.

3.4.2.2.1 Background

3.4.2.2.1.1 Injury

Injury refers to the direct effects on the tissues or organs of an animal due to exposure to pressure waves. Injury in marine mammals can be caused directly by exposure to explosions. Section 3.0.4.7

(Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on injury and the framework used to analyze this potential impact.

Injury due to Explosives

Explosive injury to marine mammals would consist of primary blast injury, which refers to those injuries that result from the compression of a body exposed to a blast wave and is usually observed as barotrauma of gas-containing structures (e.g., lung and gut) and structural damage to the auditory system (Greaves et al., 1943; Office of the Surgeon General, 1991; Richmond et al., 1973). The near instantaneous high magnitude pressure change near an explosion can injure an animal where tissue material properties significantly differ from the surrounding environment, such as around air-filled cavities such as in the lungs or gastrointestinal tract. Large pressure changes at tissue-air interfaces in the lungs and gastrointestinal tract may cause tissue rupture, resulting in a range of injuries depending on degree of exposure. The lungs are typically the first site to show any damage, while the solid organs (e.g., liver, spleen, and kidney) are more resistant to blast injury (Clark & Ward, 1943). Recoverable injuries would include slight lung injury, such as capillary interstitial bleeding, and contusions to the gastrointestinal tract. More severe injuries, such as tissue lacerations, major hemorrhage, organ rupture, or air in the chest cavity (pneumothorax), would significantly reduce fitness and likely cause death in the wild. Rupture of the lung may also introduce air into the vascular system, producing air emboli that can cause a stroke or heart attack by restricting oxygen delivery to critical organs.

If an animal is exposed to an explosive blast underwater, the likelihood of injury depends on the charge size, the geometry of the exposure (distance to the charge, depth of the animal and the charge), and the size of the animal. In general, an animal would be less susceptible to injury near the water surface because the pressure wave reflected from the water surface would interfere with the direct path pressure wave, reducing positive pressure exposure. Susceptibility would increase with depth, until normal lung collapse (due to increasing hydrostatic pressure) and increasing ambient pressures again reduce susceptibility. See Appendix H (Acoustic and Explosive Concepts) for an overview of explosive propagation and an explanation of explosive effects on gas cavities.

The only known occurrence of mortality or injury to a marine mammal due to a Navy training or testing event involving explosives occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area had been used for underwater demolitions training for at least three decades without prior known incident. On this occasion, however, a group of approximately 100–150 long-beaked common dolphins entered the mitigation zone surrounding an area where a time-delayed firing device had been initiated on an explosive with a net explosive weight of 8.76 pounds (lb.) (3.97 kilograms [kg]) placed at a depth of 48 ft. (14.6 m). Approximately one minute after detonation, three animals were observed dead at the surface. The Navy recovered those animals and transferred them to the local stranding network for necropsy. A fourth animal was discovered stranded and dead 42 NM to the north of the detonation three days later. It is unknown exactly how close those four animals were to the detonation. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil & St Leger, 2011).

Relatively little is known about auditory system trauma in marine mammals resulting from explosive exposure, although it is assumed that auditory structures would be vulnerable to blast injuries. Auditory trauma was found in two humpback whales that died following the detonation of a 5,000 kg explosive used off Newfoundland during demolition of an offshore oil rig platform (Ketten et al., 1993), but the proximity of the whales to the detonation was unknown. Eardrum rupture was examined in submerged terrestrial mammals exposed to underwater explosions (Richmond et al., 1973; Yelverton et al., 1973); however, results may not be applicable to the anatomical adaptations for underwater hearing in marine mammals. In this discussion, primary blast injury to auditory tissues is considered gross structural tissue damage distinct from threshold shift or other auditory effects (see Section 3.4.2.2.1.2, Hearing Loss).

Controlled tests with a variety of lab animals (mice, rats, dogs, pigs, sheep, and other species) are the best data sources on actual injury to mammals due to underwater exposure to explosions. In the early 1970s, the Lovelace Foundation for Medical Education and Research conducted a series of tests in an artificial pond at Kirtland Air Force Base, New Mexico, to determine the effects of underwater explosions on mammals, with the goal of determining safe ranges for human divers. The resulting data were summarized in two reports (Richmond et al., 1973; Yelverton et al., 1973). Specific physiological observations for each test animal are documented in Richmond et al. (1973). Gas-containing internal organs, such as lungs and intestines, were the principal damage sites in submerged terrestrial mammals; this is consistent with earlier studies of mammal exposures to underwater explosions in which lungs were consistently the first areas to show damage, with less consistent damage observed in the gastrointestinal tract (Clark & Ward, 1943; Greaves et al., 1943). Results from all of these tests suggest two explosive metrics are predictive of explosive injury: peak pressure and impulse.

Impulse as a Predictor of Explosive Injury

In the Lovelace studies, acoustic impulse was found to be the metric most related to degree of injury, and the size of an animal's gas-containing cavities was thought to play a role in blast injury susceptibility. The lungs of most marine mammals are similar in proportion to overall body size as those of terrestrial mammals, so the magnitude of lung damage in the tests may approximate the magnitude of injury to marine mammals when scaled for body size. Within the marine mammals, mysticetes and deeper divers (e.g., Kogiidae, Physeteridae, Ziphiidae) tend to have lung-to-body size ratios that are smaller and more similar to terrestrial animal ratios than the shallow diving odontocetes (e.g., Phocoenidae, Delphinidae) and pinnipeds (Fahlman et al., 2014a; Piscitelli et al., 2010). The use of test data with smaller lung-to-body ratios to set injury thresholds may result in a more conservative estimate of potential for damaging effects (i.e., lower thresholds) for animals with larger lung-to-body ratios.

For these shallow exposures of small terrestrial mammals (masses ranging from 3.4 to 50 kg) to underwater detonations, Richmond et al. (1973) reported that no blast injuries were observed when exposures were less than 6 pounds per square inch (psi) per millisecond (psi-ms) (40 pascals second [Pa-s]), no instances of slight lung hemorrhage occurred below 20 psi-ms (140 Pa-s), and instances of no lung damage were observed in some exposures at higher levels up to 40 psi-ms (280 Pa-s). An impulse of 34 psi-ms (230 Pa-s) resulted in about 50 percent incidence of slight lung hemorrhage. About half of the animals had gastrointestinal tract contusions (with slight ulceration, i.e., some perforation of the mucosal layer) at exposures of 25–27 psi-ms (170–190 Pa-s). Lung injuries were found to be slightly more prevalent than gastrointestinal tract injuries for the same exposure.

The Lovelace subject animals were exposed near the water surface; therefore, depth effects were not discernible in this data set. In addition, this data set included only small terrestrial animals, whereas marine mammals may be several orders of magnitude larger and have respiratory structures adapted for the high pressures experienced at depth. Goertner (1982) examined how lung cavity size would affect susceptibility to blast injury by considering both marine mammal size and depth in a bubble oscillation model of the lung. Animal depth relates to injury susceptibility in two ways: injury is related to the relative increase in explosive pressure over hydrostatic pressure, and lung collapse with depth reduces the potential for air cavity oscillatory damage. The period over which an impulse must be delivered to cause damage is assumed to be related to the natural oscillation period of an animal's lung, which depends on lung size.

Because gas-containing organs are more vulnerable to primary blast injury, adaptations for diving that allow for collapse of lung tissues with depth may make animals less vulnerable to lung injury with depth. Adaptations for diving include a flexible thoracic cavity, distensible veins that can fill space as air compresses, elastic lung tissue, and resilient tracheas with interlocking cartilaginous rings that provide strength and flexibility (Ridgway, 1972). Older literature suggested complete lung collapse depths at approximately 70 m for dolphins (Ridgway & Howard, 1979) and 20–50 m for phocid seals (Falke et al., 1985; Kooyman et al., 1972). Follow-on work by Kooyman and Sinnett (1982), in which pulmonary shunting was studied in harbor seals and sea lions, suggested that complete lung collapse for these species would be about 170 m and about 180 m, respectively. More recently, evidence in sea lions suggests that complete collapse might not occur until depths as great as 225 m; although the depth of collapse and depth of the dive are related, sea lions can affect the depth of lung collapse by varying the amount of air inhaled on a dive (McDonald & Ponganis, 2012). This is an important consideration for all divers who can modulate lung volume and gas exchange prior to diving via the degree of inhalation and during diving via exhalation (Fahlman et al., 2009); indeed, there are noted differences in pre-dive respiratory behavior, with some marine mammals exhibiting pre-dive exhalation to reduce the lung volume [e.g., phocid seals (Kooyman et al., 1973)].

Peak Pressure as a Predictor of Explosive Injury

High instantaneous peak pressures can cause damaging tissue distortion. Goertner (1982) suggested a peak overpressure gastrointestinal tract injury criterion because the size of gas bubbles in the gastrointestinal tract are variable, and their oscillation period could be short relative to primary blast wave exposure duration. The potential for gastrointestinal tract injury, therefore, may not be adequately modeled by the single oscillation bubble methodology used to estimate lung injury due to impulse. Like impulse, however, high instantaneous pressures may damage many parts of the body, but damage to the gastrointestinal tract is used as an indicator of any peak pressure-induced injury due to its vulnerability.

Older military reports documenting exposure of human divers to blast exposure generally describe peak pressure exposures around 100 psi (237 dB re 1 µPa peak) to feel like slight pressure or stinging sensation on skin, with no enduring effects (Christian & Gaspin, 1974). Around 200 psi, the shock wave felt like a blow to the head and chest. Data from the Lovelace Foundation experiments show instances of gastrointestinal tract contusions after exposures up to 1147 psi peak pressure, while exposures of up to 588 psi peak pressure resulted in many instances of no observed gastrointestinal tract effects. The lowest exposure for which slight contusions to the gastrointestinal tract were reported was 237 dB re 1 µPa peak. As a vulnerable gas-containing organ, the gastrointestinal tract is vulnerable to both high peak pressure and high impulse, which may vary to differing extents due to blast exposure conditions (i.e., animal depth, distance from the charge). This likely explains the range of effects seen at similar peak pressure exposure levels and shows the utility of considering both peak pressure and impulse when analyzing the potential for injury due to explosives.

3.4.2.2.1.2 Hearing Loss

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received SPL, temporal pattern, and duration. The frequencies affected by hearing loss may vary depending on the exposure frequency, with frequencies at and above the exposure frequency most strongly affected. The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies. Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on hearing loss and the framework used to analyze this potential impact.

Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative. There are no direct measurements of hearing loss in marine mammals due to exposure to explosive sources. The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (e.g., short duration and fast rise time) with other impulsive sounds such as those produced by air guns. General research findings regarding TTS and PTS in marine mammals, as well as findings specific to exposure to other impulsive sound sources, are discussed in Section 3.4.2.1.1.2 (Hearing Loss).

Threshold Shift due to Impulsive Sound Sources

Marine mammal TTS data from impulsive sources are limited to two studies with measured TTS of 6 dB or more: Finneran et al. (2002) reported behaviorally measured TTSs of 6 and 7 dB in a beluga exposed to single impulses from a seismic water gun, and Lucke et al. (2009) reported auditory evoked potential-measured TTS of 7–20 dB in a harbor porpoise exposed to single impulses from a seismic air gun.

In addition to these data, Kastelein et al. (2015a) reported behaviorally measured mean TTS of 4 dB at 8 kHz and 2 dB at 4 kHz after a harbor porpoise was exposed to a series of impulsive sounds produced by broadcasting underwater recordings of impact pile driving strikes through underwater sound projectors. The cumulative SEL was approximately 180 dB re 1 $\mu Pa^2 s$. The pressure waveforms for the simulated pile strikes exhibited significant “ringing” not present in the original recordings, and most of the energy in the broadcasts was between 500 and 800 Hz. As a result, some questions exist regarding whether the fatiguing signals were representative of underwater pressure signatures from impact pile driving.

Several impulsive noise exposure studies have also been conducted without behaviorally measurable TTS. Finneran et al. (2000) exposed dolphins and belugas to single impulses from an “explosion simulator,” and Finneran et al. (2015) exposed three dolphins to sequences of 10 impulses from a seismic air gun (maximum cumulative SEL = 193 to 195 dB re 1 $\mu Pa^2 s$, peak SPL = 196 to 210 dB re 1 μPa) without measurable TTS. Finneran et al. (2003b) exposed two sea lions to single impulses from an arc-gap transducer with no measurable TTS (maximum unweighted SEL = 163 dB re 1 $\mu Pa^2 s$, peak SPL = 183 dB re 1 μPa).

3.4.2.2.1.3 Physiological Stress

Marine mammals naturally experience stress within their environment and as part of their life histories. The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction). Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on physiological stress and the framework used to analyze this potential impact.

There are no direct measurements of physiological stress in marine mammals due to exposure to explosive sources. General research findings regarding physiological stress in marine mammals due to exposure to sound and other stressors are discussed in detail in Section 3.4.2.1.1.3 (Physiological Stress). Because there are many unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, it is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

3.4.2.2.1.4 Masking

Masking occurs when one sound, distinguished as the "noise," interferes with the detection, discrimination, or recognition of another sound. The quantitative definition of masking is the amount in decibels an auditory detection, discrimination, or recognition threshold is raised in the presence of a masker (Erbe et al., 2015). As discussed in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking can lead to vocal changes (e.g., Lombard effect, increasing amplitude, or changing frequency) and behavior changes (e.g., cessation of foraging, leaving an area) to both signalers and receivers, in an attempt to compensate for noise levels (Erbe et al., 2016).

There are no direct observations of masking in marine mammals due to exposure to explosive sources. Potential masking from explosive sounds is likely to be similar to masking studied for other impulsive sounds such as air guns. Masking could occur in mysticetes due to the overlap between their low-frequency vocalizations and the dominant frequencies of air gun pulses, however, masking in odontocetes is less likely unless the seismic survey activity is in close range when the pulses are more broadband. For example, differential vocal responses in marine mammals were documented in the presence of seismic survey noise. An overall decrease in vocalizations during active surveying was noted in large marine mammal groups (Potter et al., 2007), while blue whale feeding/social calls increased when seismic exploration was underway (Di Lorio & Clark, 2010), indicative of a possible compensatory response to the increased noise level. Bowhead whales were found to increase call rates in the presence of seismic air gun noise at lower received levels (below 100 dB re 1 μPa^2s cumulative SEL), but once the received level rose above 127 dB re 1 μPa^2s cumulative SEL the call rate began decreasing, and stopped altogether once received levels reached 170 dB re 1 μPa^2s cumulative SEL (Blackwell et al., 2015). Nieukirk et al. (2012) recorded both seismic surveys and fin whale 20 Hz calls at various locations around the mid-Atlantic Ocean and hypothesized that distant seismic noise could mask those calls, thereby decreasing the communication range of fin whales, whose vocalizations may propagate over 400 km to reach conspecifics (Spiesberger & Fristrup, 1990). A spotted and ringed seal in captivity were exposed to seismic air gun sounds recorded within 1 km and 30 km of an air gun survey conducted in shallow (<40 m.) water. They were then tested on their ability to detect a 500 ms upsweep centered at 100 Hz at different points in the air gun pulse (start, middle, and end). Based on these results, a 100 Hz vocalization with a source level of 130 dB re 1 µPa would not be detected above a seismic survey 1 km away unless the animal was within 1–5 m, and would not be detected above a survey 30 km away beyond 46 m (Sills et al., 2017).

3.4.2.2.1.5 Behavioral Reactions

As discussed in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), any stimuli in the environment can cause a behavioral response in marine mammals, including noise from explosions. There are few direct observations of behavioral reactions from marine mammals due to exposure to explosive sounds. Lammers et al. (2017) recorded dolphin detections near naval mine neutralization exercises and found that although the immediate response (within 30 seconds of the explosion) was an increase in whistles relative to the 30 seconds before the explosion, there was a reduction in daytime acoustic activity during the day of and the day after the exercise within 6 km. However, the nighttime activity did not seem to be different than that prior to the exercise, and two days after there appeared to be an increase in daytime acoustic activity, indicating a rapid return to the area by the dolphins (Lammers et al., 2017). Vallejo et al. (2017) report on boat-based line-transect surveys which were run over 10 years in an area where an offshore wind farm was built; these surveys included the periods of preconstruction, construction, and post-construction. Harbor porpoise were observed throughout the area during all three phases, but were not detected within the footprint of the windfarm during the construction phase, and were overall less frequent throughout the study area. However, they returned after the construction was completed at a slightly higher level than in the preconstruction phase. Furthermore, there was no large-scale displacement of harbor porpoises during construction, and in fact their avoidance behavior only occurred out to about 18 km, in contrast to the approximately 25 km avoidance distance found in other windfarm construction and pile driving monitoring efforts.

Impulsive signals, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle responses or avoidance responses. However, at long distances the rise time increases as the signal duration lengthens (similar to a “ringing” sound), making the impulsive signal more similar to a non-impulsive signal. Behavioral reactions from explosive sounds are likely to be similar to reactions studied for other impulsive sounds, such as those produced by air guns and impact pile driving. Data on behavioral responses to impulsive sound sources are limited across all marine mammal groups, with only a few studies available for mysticetes and odontocetes. Most data have come from seismic surveys that occur over long durations (e.g., on the order of days to weeks), and typically utilize large multi-air gun arrays that fire repeatedly. While seismic data provide the best available science for assessing behavioral responses to impulsive sounds by marine mammals, it is likely that these responses represent a worst-case scenario compared to responses to explosives used in Navy activities, which would typically consist of single impulses or a cluster of impulses, rather than long-duration, repeated impulses.

Mysticetes

Baleen whales have shown a variety of responses to impulsive sound sources, including avoidance, attraction to the source, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Gordon et al., 2003; McCauley et al., 2000; Richardson et al., 1985; Southall et al., 2007). Studies have been conducted on many baleen whale species, including gray, humpback, blue, fin and bowhead whales; it is assumed that these responses are representative of all baleen whale species. The behavioral state of the whale seems to be an integral part of whether or not the animal responds and how they respond, as does the location and movement of the sound source, more than the received level of the sound.

Migratory behavior seems to lead to a higher likelihood of response, with some species demonstrating more sensitivity than others. For example, migrating gray whales showed avoidance responses to seismic vessels at received levels between 164 and 190 dB re 1 µPa (Malme et al., 1986, 1988). Similarly, migrating humpback whales showed avoidance behavior at ranges of 5–8 km from a seismic array during observational studies and controlled exposure experiments in one Australian study (McCauley et al., 1998), and in another Australian study decreased their dive times and reduced their swimming speeds (Dunlop et al., 2015). However, when comparing received levels and behavioral responses when using ramp-up versus a constant noise level of air guns, humpback whales did not change their dive behavior but did deviate from their predicted heading and decrease their swim speeds (Dunlop et al., 2016). In addition, the whales demonstrated more course deviation during the constant source trials but reduced travel speeds more in the ramp-up trials; in either case there was no dose-response relationship with the received level of the air gun noise, and similar responses were observed in control trials with vessel movement but no air guns, so some of the response was likely due to the presence of the vessel and not the received level of the air guns. When looking at the relationships between proximity, received level, and behavioral response, Dunlop et al. (2017) used responses to two different air guns and found responses occurred more towards the smaller, closer source than to the larger source at the same received level, demonstrating the importance of proximity. Responses were found to be more likely when the source was within 3 km or above 140 dB re 1 µPa, although responses were variable and some animals did not respond at those values while others responded below them. In addition, responses were generally small, with course deviations of only around 500 m, and short-term (Dunlop et al., 2017). McDonald et al. (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 10 km from the seismic vessel (estimated received level 143 dB re 1 µPa peak-to-peak). Bowhead whales seem to be the most sensitive species, perhaps due to a higher overlap between bowhead whale distribution and seismic surveys in Arctic and sub-Arctic waters, as well as a recent history of being hunted. While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson et al., 1995b), some whales avoided vessels by more than 20 km at received levels as low as 120 dB re 1 µPa. Additionally, Malme et al. (1988) observed clear changes in diving and breathing patterns in bowheads at ranges up to 73 km from seismic vessels, with received levels as low as 125 dB re 1 µPa. Bowhead whales may also avoid the area around seismic surveys, from 6 to 8 km (Koski and Johnson 1987, as cited in Gordon et al., 2003) out to 20 or 30 km (Richardson et al., 1999). However, work by Robertson (2014) supports the idea that behavioral responses are contextually dependent, and that during seismic operations bowhead whales may be less "available" for counting due to alterations in dive behavior but may not have left the area after all.

In contrast, noise from seismic surveys was not found to impact feeding behavior or exhalation rates in western gray whales while resting or diving off the coast of Russia (Gailey et al., 2007; Yazvenko et al., 2007); however, the increase in vessel traffic associated with the surveys and the proximity of the vessels to the whales did affect the orientation of the whales relative to the vessels and shortened their dive-surface intervals (Gailey et al., 2016). 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 closer to the noise source, possibly indicating a reduction in net detection associated with the noise through masking or TTS. Distributions of fin and minke whales were modeled with a suite of environmental variables along with the occurrence or absence of seismic surveys, and no evidence of a decrease in sighting rates relative to seismic activity was found for either species (Vilela et al., 2016). Their distributions were driven entirely by environmental variables, particularly those linked to prey, including warmer sea surface temperatures, higher chlorophyll-a values, and higher photosynthetically available radiation (a measure of primary productivity).

Vocal responses to seismic surveys have been observed in a number of baleen whale species, including a cessation of calling, a shift in frequency, increases in amplitude or call rate, or a combination of these strategies. Blue whale feeding/social calls were found to increase when seismic exploration was underway, with seismic pulses at average received SELs of 131 dB re 1 µPa^{2}s (Di Lorio & Clark, 2010), a potentially compensatory response to increased noise level. Responses by fin whales to a 10-day seismic survey in the Mediterranean Sea included possible decreased 20-Hz call production and movement of animals from the area based on lower received levels and changes in bearings (Castellote et al., 2012). However, similarly distant seismic surveys elicited no apparent vocal response from fin whales in the mid-Atlantic Ocean; instead, Nieukirk et al. (2012) hypothesized that 20-Hz calls may have been masked from the receiver by distant seismic noise. Models of humpback whale songs off Angola showed significant seasonal and diel variation, but also showed a decrease in the number of singers with increasing received levels of air gun pulses (Cerchio et al., 2014). Bowhead whale calling rates decreased significantly at sites near seismic surveys (41–45 km) where median received levels were between 116–129 dB re 1 µPa, and did not decrease at sites further from the seismic surveys (greater than 104 km) where median received levels were 99–108 dB re 1 µPa (Blackwell et al., 2013). In fact, bowhead whale calling rates increased at the lower received levels, began decreasing at around 127 dB re 1 µPa^{2}s cumulative SEL, and ceased altogether at received levels over 170 dB re 1 µPa^{2}s cumulative SEL (Blackwell et al., 2015). Similar patterns were observed for bowhead vocalizations in the presence of tonal sounds associated with drilling activities, and were amplified in the presence of both the tonal sounds and air gun pulses (Blackwell et al., 2017).

Mysticetes seem to be the most sensitive taxonomic group of marine mammals to impulsive sound sources, with possible avoidance responses occurring out to 30 km and vocal changes occurring in response to sounds over 100 km away. However, responses appear to be behaviorally mediated, with most avoidance responses occurring during migration behavior and little observed response during feeding behavior. These response patterns are likely to hold true for Navy impulsive sources; however, Navy impulsive sources would largely be stationary (e.g., explosives fired at a fixed target), and short-term (on the order of hours rather than days or weeks) than were found in these studies, and so responses would likely occur in closer proximity or not at all.

Odontocetes

Few data are available on odontocete responses to impulsive sound sources, with only a few studies on responses to seismic surveys, pile driving, and construction activity available. However, odontocetes appear to be less sensitive to impulsive sound than mysticetes, with responses occurring at much closer distances. This may be due to the predominance of low-frequency sound associated with these sources that propagates long distances and overlaps with the range of best hearing for mysticetes but is below that range for odontocetes. The exception to this is the harbor porpoise, which has been shown to be highly sensitive to most sound sources, avoiding both stationary (e.g., pile driving) and moving (e.g., seismic survey vessels) impulsive sound sources out to approximately 20 km (e.g., Haelters et al., 2014; Pirotta et al., 2014). However, even this response is short-term, with porpoises returning to the area within hours after the cessation of the noise.

Madsen et al. (2006a) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic air gun surveys. Sound sources were from approximately 2 to 7 NM away from the whales, and received levels were as high as 162 dB SPL re 1 µPa (Madsen et al., 2006). The whales showed no horizontal avoidance, although one whale rested at the water's surface for an extended period of time until air guns ceased firing (Miller et al., 2009). While the remaining whales continued to execute foraging dives throughout exposure, tag data suggested there may have been subtle effects of noise on foraging behavior (Miller et al., 2009). Similarly, Weir (2008) observed that seismic air gun surveys along the Angolan coast did not significantly reduce the encounter rate of sperm whales during the 10-month survey period, nor were avoidance behaviors to air gun impulsive sounds observed. In contrast, Atlantic spotted dolphins did show a significant, short-term avoidance response to air gun impulses within approximately 1 km of the source (Weir, 2008). The dolphins were observed at greater distances from the vessel when the air gun was in use, and when the air gun was not in use they readily approached the vessel to bow ride.

Captive bottlenose dolphins sometimes vocalized or were reluctant to return to the test station after exposure to single impulses from a seismic water gun (Finneran et al., 2002). When exposed to multiple impulses from a seismic air gun, some dolphins turned their heads away from the sound source just before the impulse, showing that they could anticipate the timing of the impulses and perhaps reduce the received level (Finneran et al., 2015). During construction (including the blasting of old bastions) of a bridge over a waterway commonly used by the Tampa Bay, FL, stock of bottlenose dolphins, the use of the area by females decreased while males displayed high site fidelity and continued using the area, perhaps indicating differential habitat uses between the sexes (Weaver, 2015).

A study was conducted on the response of harbor porpoises to a seismic survey using aerial surveys and C-PODs (an autonomous recording device that counts odontocete clicks); the animals appeared to have left the area of the survey and decreased their foraging activity within 5–10 km, as evidenced by both a decrease in vocalizations near the survey and an increase in vocalizations at a distance (Pirotta et al., 2014; Thompson et al., 2013). However, the animals returned within a day after the air gun operation ceased, and the decrease in occurrence over the survey period was small relative to the observed natural seasonal decrease compared to the previous year. A number of studies (Brandt et al., 2011; Dähne et al., 2014; Haelters et al., 2014; Thompson et al., 2010; Tougaard et al., 2005; Tougaard et al., 2009) also found strong avoidance responses by harbor porpoises out to 20 km during pile driving; however, all studies found that the animals returned to the area after the cessation of pile driving. When bubble curtains were deployed around pile driving, the avoidance distance appeared to be reduced to half that distance (12 km), and the response only lasted about five hours rather than a day before the animals returned to the area (Dähne et al., 2017). Kastelein et al. (2013b) exposed a captive harbor porpoise to impact pile driving sounds, and found that above 136 dB re 1 µPa (zero-to-peak) the animal's respiration rates increased, and at higher levels it jumped more frequently. Bergstrom et al. (2014) found that although there was a high likelihood of acoustic disturbance during wind farm construction (including pile driving), the impact was short-term. Graham et al. (2017) assessed the occurrence of bottlenose dolphins and harbor porpoises over different area and time scales with and without impact and vibratory pile driving. While there were fewer hours with bottlenose dolphin detections and reduced detection durations within the pile driving area and increased detection durations outside the area, the effects sizes were small, and the reduced harbor porpoise encounter duration was attributed to seasonal changes outside the influence of the pile driving. However, received levels in this area were lower due to propagation effects than in the other areas described above, which may have led to the lack of or reduced response.

Odontocete behavioral responses to impulsive sound sources are likely species- and context-dependent, with most species demonstrating little to no apparent response. Responses might be expected within close proximity to a noise source, under specific behavioral conditions such as females with offspring, or for sensitive species such as harbor porpoises.

3.4.2.2.1.6 Stranding

When a marine mammal (alive or dead) 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 & Lounsbury, 2005;

Perrin & Geraci, 2002). Specifically, under U.S. law, a stranding is an event in the wild where: "(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 U.S.C. section 1421h).

Impulsive sources (e.g., explosions) also have the potential to contribute to strandings, but such occurrences are even less common than those that have been related to certain sonar activities. During a Navy training event on March 4, 2011, at the Silver Strand Training Complex in San Diego, California, three long-beaked common dolphins were killed by an underwater detonation. Further details are provided above. Discussions of mitigation measures associated with these and other training and testing events are presented in Chapter 5 (Mitigation).

3.4.2.2.1.7 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. For additional information on the determination of long-term consequences, see Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions, masking, and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. For example, a lost reproductive opportunity could be a measurable cost to the individual; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences.

3.4.2.2.2 Impacts from Explosive Stressors

Marine mammals could be exposed to energy, sound, and fragments from explosions in the water and near the water surface associated with the proposed activities. Energy from an explosion is capable of causing mortality, injury, hearing loss, a behavioral response, masking, or physiological stress, depending on the level and duration of exposure.

The death of an animal would eliminate future reproductive potential, which is considered in the analysis of potential long-term consequences to the population. Exposures that result in non-auditory injuries or 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 is likely to recover quickly with little significant effect.

Explosions in the ocean or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. These sounds, which are within the audible range of most marine mammals, could cause behavioral reactions, masking, and elevated physiological stress. 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). Sounds from explosives could also mask biologically important sounds; however, the duration of individual sounds is very short, reducing the likelihood of substantial auditory masking.

3.4.2.2.2.1 Methods for Analyzing Impacts from Explosives

The Navy performed a quantitative analysis to estimate the number of times that marine mammals could be impacted by explosions used during Navy training and testing activities. The Navy's quantitative analysis to determine impacts on marine mammals uses the Navy Acoustic Effects Model to produce initial estimates of the number of instances that animals may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of procedural mitigation measures. The steps of this quantitative analysis are described in Section 3.0.1.2 (Navy's Quantitative Analysis to Determine Impacts on Sea Turtles and Marine Mammals), which takes into account:

- criteria and thresholds used to predict impacts from explosives (see below)
- the density and spatial distribution of marine mammals
- the influence of environmental parameters (e.g., temperature, depth, salinity) on sound propagation and explosive energy when estimating the received sound level and pressure on the animals

A detailed explanation of this analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018a).

Criteria and Thresholds used to Estimate Impacts to Marine Mammals from Explosives

Mortality and Injury from Explosives

As discussed above in Section 3.4.2.2.1.1 (Injury), two metrics have been identified as predictive of injury: impulse and peak pressure. Peak pressure contributes to the "crack" or "stinging" sensation of a blast wave, compared to the "thump" associated with received impulse. Older military reports documenting exposure of human divers to blast exposure generally describe peak pressure exposures around 100 psi (237 dB re 1 µPa SPL peak) to feel like slight pressure or stinging sensation on skin, with no enduring effects (Christian & Gaspin, 1974).

Because data on explosive injury do not indicate a set threshold for injury, rather a range of risk for explosive exposures, two sets of criteria are provided for use in non-auditory injury assessment. The exposure thresholds are used to estimate the number of animals that may be affected during Navy training and testing activities (Table 3.4-15). The thresholds for the farthest range to effect are based on the received level at which one percent risk is predicted and are useful for assessing potential effects to marine mammals and the level of potential impacts covered by the mitigation zones. Increasing animal mass and increasing animal depth both increase the impulse thresholds (i.e., decrease susceptibility), whereas smaller mass and decreased animal depth reduce the impulse thresholds (i.e., increase susceptibility). For impact assessment, marine mammal populations are assumed to be 70 percent adult and 30 percent calf/pup. Sub-adult masses are used to determine onset of effect, in order to estimate the farthest range at which an effect may first be observable. The derivation of these injury criteria and the species mass estimates are provided in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a).

Table 3.4-15: Criteria to Quantitatively Assess Non-Auditory Injury Due to Underwater Explosions

Impact Category	*Impact Threshold*	*Threshold for Farthest Range to Effect*[2]
Mortality[1]	$144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s	$103\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
Injury[1]	$65.8\mathrm{M}^{1/3}\left(1+\frac{\mathrm{D}}{10.1}\right)^{1/6}$ Pa-s	$47.5\mathrm{M}^{1/3}\left(1+\frac{\mathrm{D}}{10.1}\right)^{1/6}$ Pa-s
	243 dB re 1 µPa SPL peak	237 dB re 1 µPa SPL peak

[1] Impulse delivered over 20 percent of the estimated lung resonance period. See U.S. Department of the Navy (2017a).

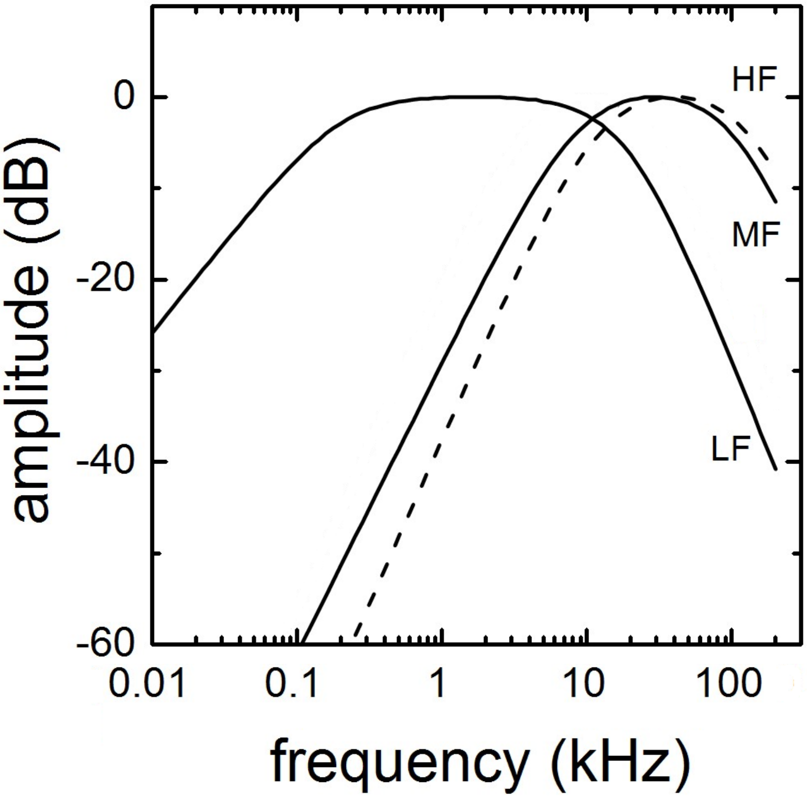
[2] Threshold for one percent risk used to assess mitigation effectiveness.

Notes: D = animal depth (m), dB re 1 µPa = decibels referenced to 1 micropascal, M = animal mass (kg), Pa-s = Pascal-second, SPL = sound pressure level

When explosive ordnance (e.g., bomb or missile) detonates, fragments of the weapon are thrown at high-velocity from the detonation point, which can injure or kill marine mammals if they are struck. Risk of fragment injury reduces exponentially with distance as the fragment density is reduced. Fragments underwater tend to be larger than fragments produced by in-air explosions (Swisdak & Montanaro, 1992). Underwater, the friction of the water would quickly slow these fragments to a point where they no longer pose a threat. On the other hand, the blast wave from an explosive detonation moves efficiently through the seawater. Because the ranges to mortality and injury due to exposure to the blast wave are likely to far exceed the zone where fragments could injure or kill an animal, the above thresholds are assumed to encompass risk due to fragmentation.

Auditory Weighting Functions

Animals are not equally sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions are used (Figure 3.4-63). Auditory weighting functions are mathematical functions based on a generic band-pass filter and incorporate species-specific hearing abilities to calculate a weighted received sound level in units SPL or SEL. Due to the band pass nature of auditory weighting functions, they resemble an inverted "U" shape with amplitude plotted as a function of frequency. The flatter portion of the plotted function, where the amplitude is closest to zero, is the emphasized frequency range (i.e., the pass-band), while the frequencies below and above this range (where amplitude declines) are de-emphasized.

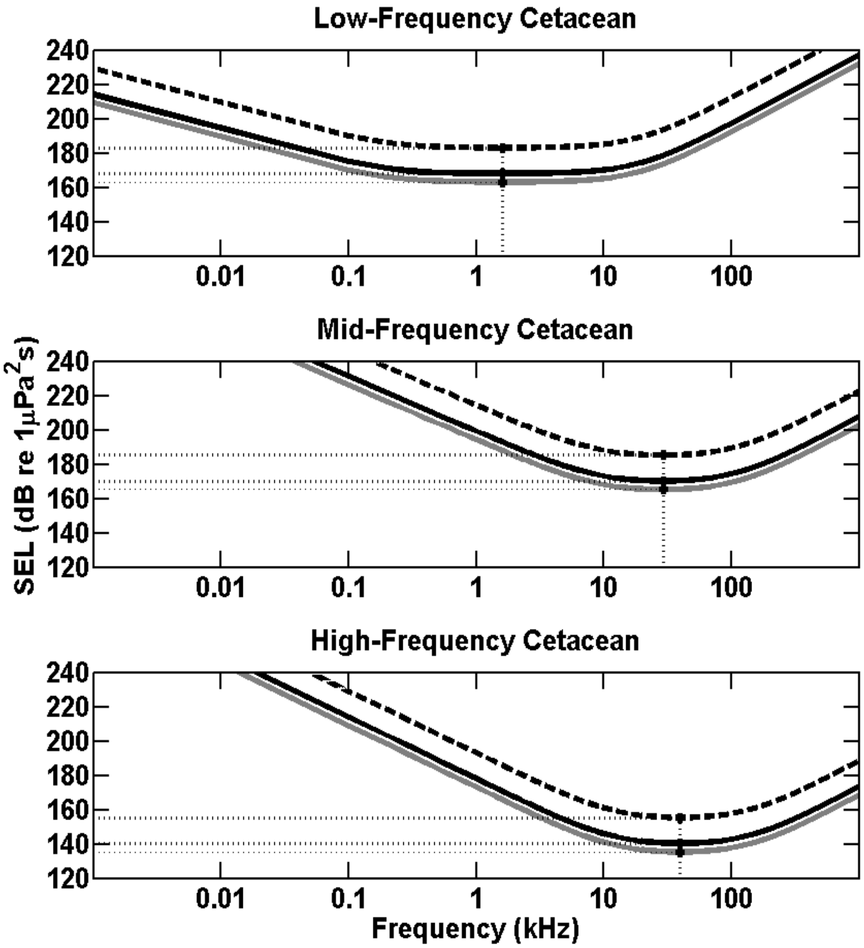


Source: See Finneran (2015) for parameters used to generate the functions and more information on weighting function derivation.
Notes: MF = mid-frequency cetacean, HF = high-frequency cetacean, LF = low-frequency cetacean

Figure 3.4-63: Navy Phase III Weighting Functions for All Species Groups

Hearing Loss from Explosives

Criteria used to define threshold shifts from explosions are derived from the two known studies designed to induce TTS in marine mammals from impulsive sources. Finneran et al. (2002) reported behaviorally measured TTS of 6 and 7 dB in a beluga exposed to single impulses from a seismic water gun, and Lucke et al. (2009) reported auditory evoked potential-measured TTS of 7–20 dB in a harbor porpoise exposed to single impulses from a seismic air gun. Since marine mammal PTS data from impulsive noise exposures do not exist, onset-PTS levels for all groups were estimated by adding 15 dB to the threshold for non-impulsive sources. This relationship was derived by Southall et al. (2007) from impulsive noise TTS growth rates in chinchillas. These frequency-dependent thresholds are depicted by the exposure functions for each group's range of best hearing (Figure 3.4-64). Weighted sound exposure thresholds for underwater explosive sounds used in the analysis are shown in Table 3.4-16.



Notes: The dark dashed curve is the exposure function for PTS onset, the solid black curve is the exposure function for TTS onset, and the light grey curve is the exposure function for behavioral response. Small dashed lines indicate the SEL threshold for behavioral response, TTS, and PTS onset at each group's most sensitive frequency (i.e., the weighted SEL threshold).

Figure 3.4-64: Navy Phase III Behavioral, TTS and PTS Exposure Functions for Explosives

Table 3.4-16: Navy Phase III Weighted Sound Exposure Thresholds for Underwater Explosive Sounds

Hearing Group	*Explosive Sound Source*				
	Behavior (SEL) weighted (dB)	*TTS (SEL) weighted (dB)*	*TTS (Peak SPL) unweighted (dB)*	*PTS (SEL) weighted (dB)*	*PTS (Peak SPL) unweighted (dB)*
Low-frequency Cetacean	163	168	213	183	219
Mid-frequency Cetacean	165	170	224	185	230
High-frequency Cetacean	135	140	196	155	202

Notes: dB = decibels, PTS = permanent threshold shift, SEL = sound exposure level, SPL = sound pressure level, TTS = temporary threshold shift

Behavioral Responses from Explosives

If more than one explosive 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 a behavioral reaction. For exercises with multiple explosions, the behavioral threshold used in this analysis is 5 dB less than the TTS onset threshold (in SEL). This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulsive TTS testing (Schlundt et al., 2000).

Some multiple explosive exercises, such as certain naval gunnery exercises, may be treated as a single event because a few explosions occur closely spaced within a very short time (a few seconds). For single explosions 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 impulses, significant behavioral reactions would not be expected to occur. This reasoning was applied to previous shock trials (63 FR 230; 66 FR 87; 73 FR 143) and is extended to the criteria used in this analysis.

Accounting for Mitigation

The Navy will implement mitigation measures to avoid or reduce potential impacts from explosives on marine mammals, as described in Section 5.3.3 (Explosive Stressors). The benefits of mitigation are conservatively factored into the analysis for Alternative 1 and Alternative 2 of the Proposed Action for training and testing. The Navy's mitigation measures are identical for both action alternatives.

Procedural mitigation measures include delaying or ceasing applicable detonations when a marine mammal is observed in a mitigation zone. The mitigation zones for explosives extend beyond the respective average ranges to mortality. Therefore, the impact analysis quantifies the potential for procedural mitigation to reduce the risk of mortality due to exposure to explosives. Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., an explosive activity) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018a).

In the quantitative analysis, consideration of mitigation measures means that, for activities that implement mitigation, model-estimated mortality is considered mitigated to the level of injury. The impact analysis does not analyze the potential for mitigation to reduce non-auditory injury, PTS, TTS, or behavioral effects, even though mitigation would also reduce the likelihood of these effects. In practice, mitigation also protects all unobserved (below the surface) animals in the vicinity, including other species, in addition to the observed animal. However, the analysis assumes that only animals sighted at the water surface would be protected by the applied mitigation. The analysis, therefore, does not capture the protection afforded to all marine species that may be near or within the mitigation zone.

The ability to observe the ranges to mortality was estimated for each training or testing event. The ability of Navy Lookouts to detect marine mammals within a mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as group size or surface active behavior). The behaviors and characteristics of some species may make them easier to detect. Certain behaviors, such as leaping and breaching, are visible from a great distance and likely increase sighting distances and detections of those species. Environmental conditions under which the training or testing activity could take place are also considered, such as sea surface conditions, weather (e.g., fog or rain), and day versus night.

The Navy will also implement mitigation measures for certain explosive activities within mitigation areas, as described in Appendix I (Geographic Mitigation Assessment). The benefits of mitigation areas are discussed qualitatively and have not been factored into the quantitative analysis process or reductions in take for the MMPA and ESA impact estimates. Mitigation areas are designed to help avoid or reduce impacts during biologically important life processes within particularly important habitat areas. Therefore, mitigation area benefits are discussed in terms of the context of impact avoidance or reduction.

3.4.2.2.2.2 Impact Ranges for Explosives

The following section provides the range (distance) over which specific physiological or behavioral effects are expected to occur based on the explosive criteria and the explosive propagation calculations from the Navy Acoustic Effects Model (Section 3.4.2.2.2.1, Methods for Analyzing Impacts from Explosives). The range to effects are shown for a range of explosive bins, from E1 (up to 0.25 lb. net explosive weight) to E12 (up to 1,000 lb. net explosive weight). Ranges are determined by modeling the distance that noise from an explosion will need to propagate to reach exposure level thresholds specific to a hearing group that would cause behavioral response, TTS, PTS, and non-auditory injury. Range to effects is important information in not only predicting impacts from explosives, but also in verifying the accuracy of model results against real-world situations and assessing the level of impact that would likely be mitigated within applicable mitigation zones.

Table 3.4-17 shows the minimum, average, and maximum ranges due to varying propagation conditions to non-auditory injury as a function of animal mass and explosive bin. Ranges to gastrointestinal tract injury typically exceed ranges to slight lung injury; therefore, the maximum range to effect is not mass-dependent. 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. Ranges to mortality, based on animal mass, are shown in Table 3.4-18.

The following tables (Table 3.4-19 through Table 3.4-24) show the minimum, average, and maximum ranges to onset of auditory and behavioral effects based on the thresholds described in Section 3.4.2.2.2.1 (Methods for Analyzing Impacts from Explosives). Ranges are provided for a representative source depth and cluster size (the number of rounds fired [or buoys dropped] within a very short duration) for each bin. For events with multiple explosions, sound from successive explosions can be expected to accumulate and increase the range to the onset of an impact based on SEL thresholds. Modeled ranges to TTS and PTS based on peak pressure for a single explosion generally exceed the modeled ranges based on SEL even when accumulated for multiple explosions. Peak pressure based ranges are estimated using the best available science; however, data on peak pressure at far distances from explosions are very limited. For additional information on how ranges to impacts from explosions were estimated, see the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018a).

Table 3.4-17: Ranges to Non-Auditory Injury (in meters) for All Marine Mammal Hearing Groups

Bin	*Range to Non-Auditory Injury (meters)*[1]
E1	12 (11–13)
E2	16 (15–16)
E3	25 (25–25)
E4	30 (30–35)
E5	40 (40–65)
E6	52 (50–60)
E7	120 (120–120)
E8	98 (90–150)
E9	123 (120–270)
E10	155 (150–430)
E11	418 (410–420)
E12	195 (180–675)

[1] Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Notes: All ranges to non-auditory injury within this table are driven by gastrointestinal tract injury thresholds regardless of animal mass.

Table 3.4-18: Ranges to Mortality (in meters) for All Marine Mammal Hearing Groups as a Function of Animal Mass

Bin	*Range to Mortality (meters) for Various Animal Mass Intervals (kg)*[1]					
	10 kg	*250 kg*	*1,000 kg*	*5,000 kg*	*25,000 kg*	*72,000 kg*
E1	3 (3–3)	1 (0–2)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
E2	4 (3–4)	2 (1–3)	1 (0–1)	0 (0–0)	0 (0–0)	0 (0–0)
E3	9 (7–10)	4 (2–8)	2 (1–2)	1 (0–1)	0 (0–0)	0 (0–0)
E4	13 (12–15)	7 (4–12)	3 (3–4)	2 (1–3)	1 (1–1)	1 (0–1)
E5	13 (12–30)	7 (4–25)	3 (2–7)	2 (1–5)	1 (1–2)	1 (0–2)
E6	16 (15–25)	9 (5–23)	4 (3–8)	3 (2–6)	1 (1–2)	1 (1–2)
E7	55 (55–55)	26 (18–40)	13 (11–15)	9 (7–10)	4 (4–4)	3 (2–3)
E8	42 (25–65)	22 (9–50)	11 (6–19)	8 (4–13)	4 (2–6)	3 (1–5)
E9	33 (30–35)	20 (13–30)	10 (9–12)	7 (5–9)	4 (3–4)	3 (2–3)
E10	55 (40–170)	24 (16–35)	13 (11–15)	9 (7–11)	5 (4–5)	4 (3–4)
E11	206 (200–210)	98 (55–170)	44 (35–50)	30 (25–35)	16 (14–18)	12 (10–15)
E12	86 (50–270)	35 (20–210)	16 (13–19)	11 (9–13)	6 (5–6)	5 (4–5)

[1] Average distance to mortality (meters) is depicted above the minimum and maximum distances, which are in parentheses for each animal mass interval.

Note: Kg = kilogram

Table 3.4-19: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for High-Frequency Cetaceans

Range to Effects for Explosives: High-Frequency Cetaceans[1]					
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***	***Range to Behavioral (meters)***
E1	0.1	1	353 (340–370)	1,303 (1,275–1,775)	2,139 (2,025–4,275)
		18	1,031 (1,025–1,275)	3,409 (2,525–8,025)	4,208 (3,025–11,525)
E2	0.1	1	431 (410–700)	1,691 (1,525–2,775)	2,550 (2,025–4,525)
		5	819 (775–1,275)	2,896 (2,275–6,775)	3,627 (2,525–10,275)
E3	0.1	1	649 (625–700)	2,439 (2,025–4,525)	3,329 (2,525–7,525)
		12	1,682 (1,525–2,275)	4,196 (3,025–11,525)	5,388 (4,525–16,275)
	18.25	1	720 (675–775)	4,214 (2,275–6,275)	7,126 (3,525–8,775)
		12	1,798 (1,525–2,775)	10,872 (4,525–13,775)	14,553 (5,525–17,775)
E4	10	2	1,365 (1,025–2,775)	7,097 (4,275–10,025)	9,939 (5,025–15,275)
	60	2	1,056 (875–2,275)	3,746 (2,775–5,775)	5,262 (3,025–7,775)
E5	0.1	20	2,926 (1,525–6,275)	6,741 (4,525–16,025)	9,161 (4,775–20,025)
	30	20	4,199 (3,025–6,275)	13,783 (8,775–17,775)	17,360 (10,525–22,775)
E6	0.1	1	1,031 (1,025–1,275)	3,693 (2,025–8,025)	4,659 (3,025–12,775)
	30	1	1,268 (1,025–1,275)	7,277 (3,775–8,775)	10,688 (5,275–12,525)
E7	28	1	1,711 (1,525–2,025)	8,732 (4,275–11,775)	12,575 (4,275–16,025)
E8	0.1	1	1,790 (1,775–3,025)	4,581 (4,025–10,775)	6,028 (4,525–15,775)
	45.75	1	1,842 (1,525–2,025)	9,040 (4,525–12,775)	12,729 (5,025–18,525)
E9	0.1	1	2,343 (2,275–4,525)	5,212 (4,025–13,275)	7,573 (5,025–17,025)

Table 3.4-19: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for High-Frequency Cetaceans (continued)

Range to Effects for Explosives: High-Frequency Cetaceans[1]					
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***	***Range to Behavioral (meters)***
E10	0.1	1	2,758 (2,275–5,025)	6,209 (4,275–16,525)	8,578 (5,275–19,775)
E11	45.75	1	3,005 (2,525–3,775)	11,648 (5,025–18,775)	14,912 (6,525–24,775)
	91.4	1	3,234 (2,525–4,525)	5,772 (4,775–11,775)	7,197 (5,775–14,025)
E12	0.1	1	3,172 (3,025–6,525)	7,058 (5,025–17,025)	9,262 (6,025–21,775)
		4	4,209 (3,775–10,025)	9,817 (6,275–22,025)	12,432 (7,525–27,775)

[1] Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels. PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 3.4-20: Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for High-Frequency Cetaceans

Range to Effects for Explosives: High-Frequency Cetaceans[1]			
Bin	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	745 (700–775)	1,275 (1,275–1,275)
E2	0.1	912 (380–975)	1,498 (725–1,525)
E3	0.1	1,525 (1,525–1,525)	2,397 (2,025–2,525)
	18.25	1,561 (1,525–2,775)	2,919 (2,775–3,525)
E4	10	2,076 (1,775–2,525)	5,565 (3,525–7,775)
	60	2,364 (1,775–4,775)	4,044 (2,025–5,275)
E5	0.1	2,267 (1,025–3,275)	3,093 (1,275–5,775)
	30	2,567 (2,275–2,775)	3,747 (3,025–5,275)

Table 3.4-20: Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for High-Frequency Cetaceans (continued)

Range to Effects for Explosives: High-Frequency Cetaceans[1]			
Bin	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E6	0.1	2,546 (1,275–4,525)	3,356 (1,525–6,525)
	30	3,242 (2,775–3,525)	4,598 (3,525–5,275)
E7	28	4,261 (3,025–5,025)	7,782 (3,775–12,525)
E8	0.1	3,458 (3,025–6,525)	4,324 (3,775–8,275)
	45.75	4,790 (4,275–6,525)	11,013 (4,775–23,775)
E9	0.1	3,870 (3,275–8,025)	4,620 (3,775–10,275)
E10	0.1	3,993 (2,525–9,275)	5,076 (2,775–16,025)
E11	45.75	8,388 (4,775–24,275)	17,386 (5,025–33,275)
	91.4	5,051 (4,025–7,525)	7,065 (4,275–26,525)
E12	0.1	4,519 (3,775–9,775)	5,678 (4,275–13,025)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses. PTS = permanent threshold shift, TTS = temporary threshold shift

Table 3.4-21: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Low-Frequency Cetaceans

Range to Effects for Explosives: Low-Frequency Cetaceans[1]					
Bin	*Source Depth (meters)*	*Cluster Size*	*Range to PTS (meters)*	*Range to TTS (meters)*	*Range to Behavioral (meters)*
E1	0.1	1	51 (50–55)	231 (200–250)	378 (280–410)
		18	183 (170–190)	691 (450–775)	934 (575–1,275)
E2	0.1	1	66 (65–70)	291 (220–320)	463 (330–500)
		5	134 (110–140)	543 (370–600)	769 (490–950)
E3	0.1	1	113 (110–120)	477 (330–525)	689 (440–825)
		12	327 (250–370)	952 (600–1,525)	1,240 (775–4,025)
	18.25	1	200 (200–200)	955 (925–1,000)	1,534 (1,275–1,775)
		12	625 (600–625)	5,517 (2,275–7,775)	10,299 (3,775–13,025)
E4	10	2	429 (370–600)	2,108 (1,775–2,775)	4,663 (3,025–6,025)
	60	2	367 (340–470)	1,595 (1,025–2,025)	2,468 (1,525–4,275)
E5	0.1	20	702 (380–1,275)	1,667 (850–11,025)	2,998 (1,025–19,775)
	30	20	1,794 (1,275–2,775)	8,341 (3,775–11,525)	13,946 (4,025–22,275)
E6	0.1	1	250 (190–410)	882 (480–1,775)	1,089 (625–6,525)
	30	1	495 (490–500)	2,315 (2,025–2,525)	5,446 (3,275–6,025)
E7	28	1	794 (775–900)	4,892 (2,775–6,275)	9,008 (3,775–12,525)
E8	0.1	1	415 (270–725)	1,193 (625–4,275)	1,818 (825–8,525)
	45.75	1	952 (900–975)	6,294 (3,025–9,525)	12,263 (4,275–20,025)
E9	0.1	1	573 (320–1,025)	1,516 (725–7,275)	2,411 (950–14,275)

Table 3.4-21: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Low-Frequency Cetaceans (continued)

Range to Effects for Explosives: Low-Frequency Cetaceans[1]					
Bin	*Source Depth (meters)*	*Cluster Size*	*Range to PTS (meters)*	*Range to TTS (meters)*	*Range to Behavioral (meters)*
E10	0.1	1	715 (370–1,525)	2,088 (825–28,275)	4,378 (1,025–32,275)
E11	45.75	1	1,881 (1,525–2,275)	12,425 (4,275–27,275)	23,054 (7,025–65,275)
	91.4	1	1,634 (1,275–2,525)	5,686 (3,775–11,275)	11,618 (5,525–64,275)
E12	0.1	1	790 (420–2,775)	2,698 (925–25,275)	6,032 (1,025–31,275)
		4	1,196 (575–6,025)	6,876 (1,525–31,275)	13,073 (3,775–64,275)

[1] Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.

Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 3.4-22: Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for Low-Frequency Cetaceans

Range to Effects for Explosives: Low-Frequency Cetaceans[1]			
Bin	*Source Depth (meters)*	*Range to PTS (meters)*	*Range to TTS (meters)*
E1	0.1	135 (130–140)	249 (220–270)
E2	0.1	173 (120–180)	305 (180–330)
E3	0.1	292 (240–310)	499 (330–550)
	18.25	310 (310–310)	583 (550–600)
E4	10	396 (390–420)	738 (725–750)
	60	420 (380–775)	846 (575–2,025)
E5	0.1	451 (310–525)	740 (410–1,025)
	30	521 (490–600)	971 (925–1,025)

Table 3.4-22: Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for Low-Frequency Cetaceans (continued)

Range to Effects for Explosives: Low-Frequency Cetaceans[1]			
Bin	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E6	0.1	547 (350–700)	842 (460–1,275)
	30	622 (600–650)	1,025 (1,025–1,025)
E7	28	927 (900–950)	1,524 (1,275–1,525)
E8	0.1	799 (450–925)	1,030 (575–1,775)
	45.75	1,025 (1,025–1,025)	1,778 (1,525–2,025)
E9	0.1	947 (500–1,275)	1,294 (675–3,025)
E10	0.1	1,032 (550–1,775)	1,388 (800–4,275)
E11	45.75	1,778 (1,525–2,025)	3,067 (2,275–11,275)
	91.4	1,676 (1,275–3,275)	2,442 (2,025–3,525)
E12	0.1	1,151 (625–2,525)	1,762 (900–5,275)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

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

Table 3.4-23: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Mid-Frequency Cetaceans

Range to Effects for Explosives: Mid-Frequency Cetaceans¹					
Bin	*Source Depth (meters)*	*Cluster Size*	*Range to PTS (meters)*	*Range to TTS (meters)*	*Range to Behavioral (meters)*
E1	0.1	1	25 (25–25)	116 (110–120)	199 (190–210)
		18	94 (90–100)	415 (390–440)	646 (525–700)
E2	0.1	1	30 (30–35)	146 (140–170)	248 (230–370)
		5	63 (60–70)	301 (280–410)	481 (430–675)
E3	0.1	1	50 (50–50)	233 (220–250)	381 (360–400)
		12	155 (150–160)	642 (525–700)	977 (700–1,025)
	18.25	1	40 (40–40)	202 (190–220)	332 (320–350)
		12	126 (120–130)	729 (675–775)	1,025 (1,025–1,025)
E4	10	2	76 (70–90)	464 (410–550)	783 (650–975)
	60	2	60 (60–60)	347 (310–675)	575 (525–900)
E5	0.1	20	290 (280–300)	1,001 (750–1,275)	1,613 (925–3,275)
	30	20	297 (240–420)	1,608 (1,275–2,775)	2,307 (2,025–2,775)
E6	0.1	1	98 (95–100)	430 (400–450)	669 (550–725)
	30	1	78 (75–80)	389 (370–410)	619 (600–650)
E7	28	1	110 (110–110)	527 (500–575)	1,025 (1,025–1,025)
E8	0.1	1	162 (150–170)	665 (550–700)	982 (725–1,025)
	45.75	1	127 (120–130)	611 (600–625)	985 (950–1,025)
E9	0.1	1	215 (210–220)	866 (625–1,000)	1,218 (800–1,525)

Table 3.4-23: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Mid-Frequency Cetaceans (continued)

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]					
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***	***Range to Behavioral (meters)***
E10	0.1	1	270 (250–280)	985 (700–1,275)	1,506 (875–2,525)
E11	45.75	1	241 (230–250)	1,059 (1,000–1,275)	1,874 (1,525–2,025)
	91.4	1	237 (230–270)	1,123 (900–2,025)	1,731 (1,275–2,775)
E12	0.1	1	332 (320–370)	1,196 (825–1,525)	1,766 (1,025–3,525)
		4	572 (500–600)	1,932 (1,025–4,025)	2,708 (1,275–6,775)

[1] Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.

Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 3.4-24: Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for Mid-Frequency Cetaceans

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]			
Bin	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	43 (40–45)	84 (80–90)
E2	0.1	58 (55–60)	105 (95–110)
E3	0.1	98 (95–100)	183 (170–190)
	18.25	100 (100–100)	180 (180–180)
E4	10	120 (120–120)	255 (250–260)
	60	123 (120–130)	239 (230–340)
E5	0.1	155 (150–160)	288 (270–300)
	30	168 (160–190)	310 (290–350)

Table 3.4-24: Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for Mid-Frequency Cetaceans (continued)

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]			
Bin	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E6	0.1	197 (190–210)	359 (320–400)
	30	200 (200–200)	380 (380–380)
E7	28	296 (290–300)	525 (525–525)
E8	0.1	333 (310–340)	574 (440–625)
	45.75	351 (350–370)	629 (625–725)
E9	0.1	442 (370–460)	757 (500–850)
E10	0.1	546 (420–700)	939 (550–1,275)
E11	45.75	662 (650–800)	1,104 (1,025–1,275)
	91.4	748 (600–1,525)	1,353 (1,000–2,525)
E12	0.1	663 (470–725)	1,064 (625–1,275)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

3.4.2.2.2.3 Impacts from Explosive Stressors Under the Action Alternatives

Under Alternative 1, there could be fluctuation in the amount of explosives use that could occur annually, although potential impacts would be similar from year to year. The number of impulsive sources in this SEIS/OEIS compared with the totals analyzed in the 2015 MITT Final EIS/OEIS are described in Table 2.5-1 and Table 2.5-2. This comparison applies to both Alternative 1 and Alternative 2, because the number of explosives used would be almost identical under each alternative.

The number of torpedo testing events (both explosive and non-explosive) planned under Alternative 1 testing can vary slightly from year to year; however, all other training and testing activities that involve the use of explosives would remain consistent from year to year. Alternative 1 results are presented for a maximum explosive use year; however, during most years, explosive use would be less, resulting in fewer potential impacts. The numbers of activities planned under Alternative 2 are consistent from year to year and would increase slightly compared to activities planned under Alternative 1. The numbers of explosives used under each alternative are described in Section 3.0.4.2 (Explosive Stressors).

Presentation of Estimated Impacts from the Quantitative Analysis

The results of the analysis of potential impacts on marine mammals from explosives (see above Section 3.4.2.2.2.1, Methods for Analyzing Impacts from Explosives) are discussed below. The numbers of potential impacts estimated for individual species of marine mammals from exposure to explosive energy and sound for training activities under Alternative 1 and 2 are shown in Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Additionally, estimated numbers of potential impacts from the quantitative analysis for each species are presented below (e.g., Figure 3.4-65). The most likely regions and activity categories from which the impacts could occur are displayed in the impact graphics for each species. There is a potential for impacts to occur anywhere within the Study Area where sound and energy from explosions and the species overlap, although only regions or activity categories where 0.5 percent of the impacts, or greater, are estimated to occur are graphically represented on the impact graphics below. All (i.e., grand total) estimated impacts are also included, regardless of region or category.

Mysticetes

Mysticetes may be exposed to sound and energy from explosions associated with training and testing activities throughout the year. Explosions produce sounds that are within the hearing range of mysticetes (see Section 3.4.1.6, Hearing and Vocalization). Potential impacts from explosive energy and sound include non-auditory injury, behavioral reactions, physiological stress, masking, and hearing loss. The quantitative analysis estimates the number of behavioral reactions and TTS in mysticetes. Impact ranges for mysticetes exposed to explosive sound and energy are discussed under low-frequency cetaceans in Section 3.4.2.2.2.2 (Impact Ranges for Explosives).

Mysticetes that do experience threshold shift from explosive sounds may have reduced ability to detect biologically important sounds (e.g., social vocalizations) until their hearing recovers. Recovery from threshold shift begins almost immediately after the noise exposure ceases and can take a few minutes to a few days, depending on the severity of the initial shift, to recover. TTS would recover fully and PTS would leave some residual hearing loss. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. Noise from explosions is broadband with most energy below a few hundred Hertz; therefore, any hearing loss from exposure to explosive sounds is likely to be broadband with effects predominantly at lower frequencies. During the short period that a mysticete had TTS, or permanently for PTS, social calls from conspecifics could be more difficult to detect or interpret, the ability to detect predators may be reduced, and the ability to detect and avoid sounds from approaching vessels or other stressors might be reduced. It is unclear how or if mysticetes use sound for finding prey or feeding; therefore, it is unknown whether a TTS would affect a mysticete’s ability to locate prey or rate of feeding.

Research and observations of auditory masking in marine mammals due to impulsive sounds are discussed in Section 3.4.2.2.1.4 (Masking). Explosions introduce low-frequency, broadband sounds into the environment, which could mask hearing thresholds in mysticetes that are nearby, although sounds from explosions last for only a few seconds at most. Masking due to time-isolated detonations would not be significant. Activities that have multiple detonations such as some naval gunfire exercises could create some masking for mysticetes in the area over the short duration of the event. Potential costs to mysticetes from masking are similar to those discussed above for TTS, with the primary difference being that the effects of masking are only present when the sound from the explosion is present within the water and the effect is over the moment the sound has ceased.

Research and observations (see Section 3.4.2.2.1.5, Behavioral Reactions) show that if mysticetes are exposed to impulsive sounds such as those from explosives, they may react in a variety of ways, which may include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, changing vocalization, or showing no response at all. Overall, mysticetes have been observed to be more reactive to acoustic disturbance when a noise sources is located directly on their migration route. Mysticetes disturbed while migrating could pause their migration or route around the disturbance. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Because noise from most activities using explosives is short-term and intermittent, and because detonations usually occur within a small area, behavioral reactions from mysticetes are likely to be short-term and low to moderate severity.

Physiological stress could be caused by injury or hearing loss and could accompany any behavioral reaction as well. Research and observations of physiological stress in marine mammals are discussed in Section 3.4.2.2.1.3 (Physiological Stress). Due to the short-term and intermittent use of explosives, physiological stress is also likely to be short-term and intermittent. Long-term consequences from physiological stress due to the sound of explosives would not be expected.

Blue Whale (Endangered Species Act-Listed)

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Blue whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no blue whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the unintentional taking of blue whales incidental to those activities.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 1 would not affect ESA-listed blue whales.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Blue whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no blue whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the unintentional taking of blue whales incidental to those activities.

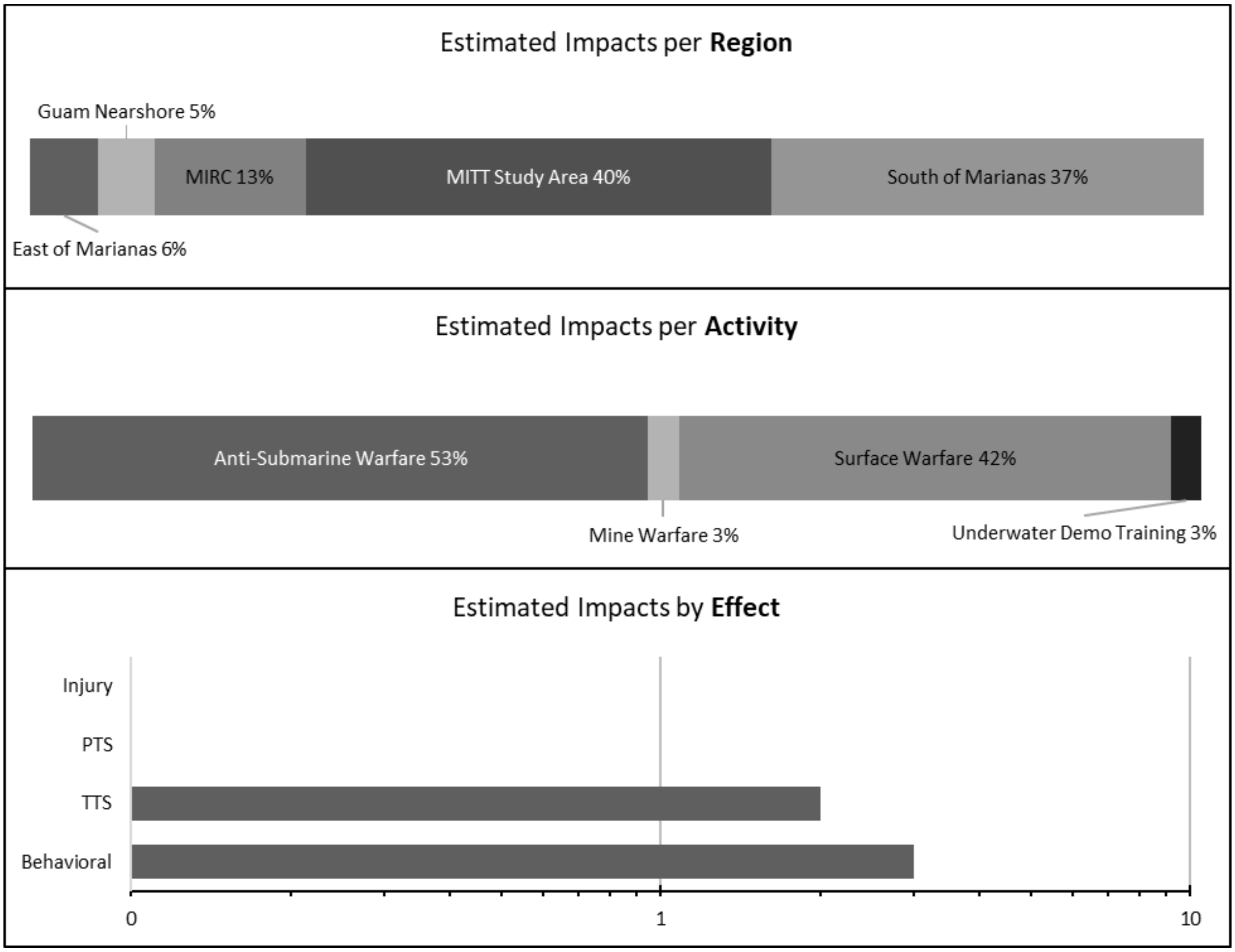
Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 2 would not affect ESA-listed blue whales.

Bryde's Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Bryde's whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS (see Figure 3.4-65 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of Bryde's whales incidental to those activities.



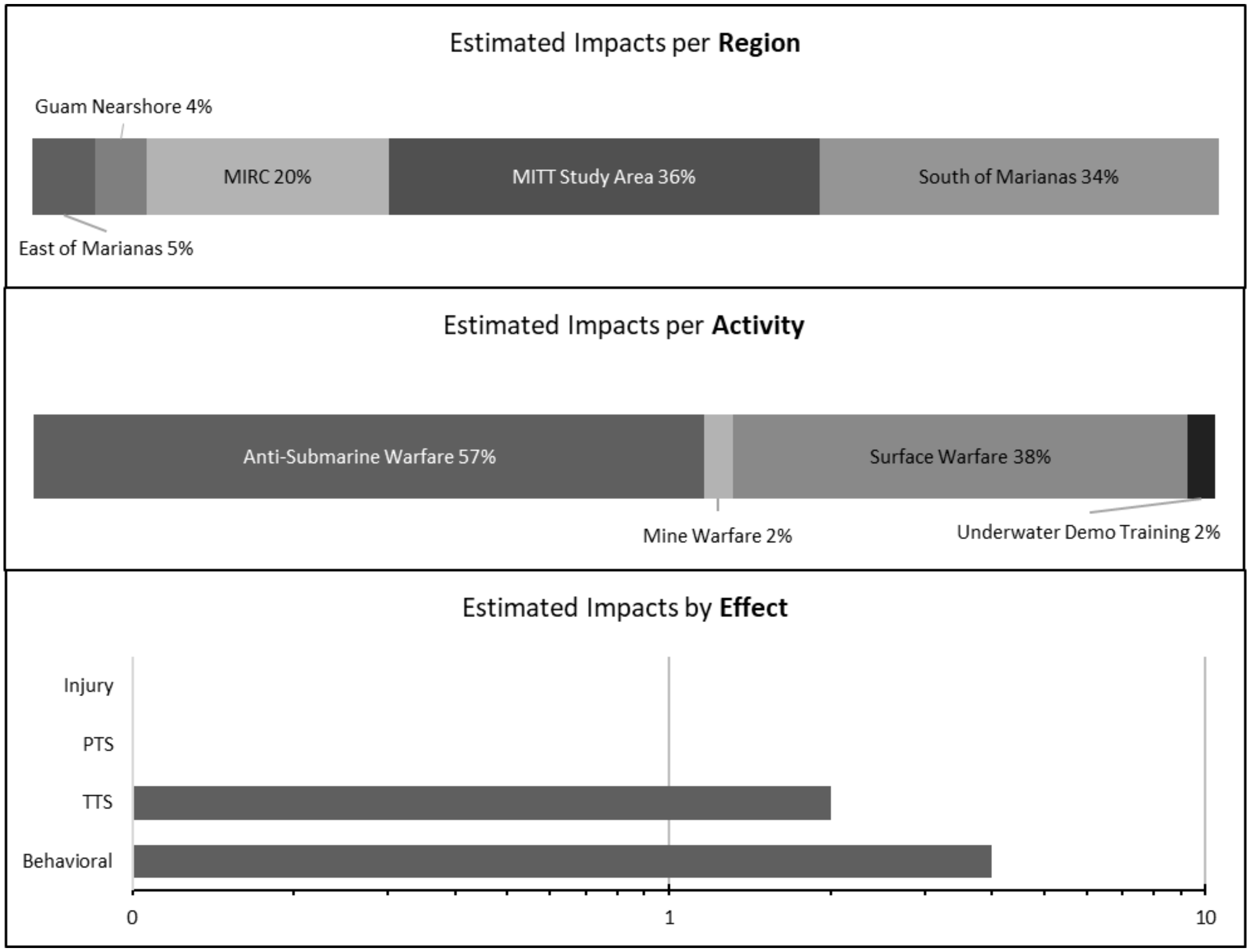
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-65: Bryde's Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly in location and number (see Figure 3.4-66) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities. The primary distinction is that explosive use would be consistent year to year under Alternative 2 and the total number of activities would increase slightly compared to Alternative 1.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of Bryde's whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-66: Bryde's Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Fin Whale (Endangered Species Act-Listed)

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Fin whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no fin whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the unintentional taking of fin whales incidental to those activities.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 1 would not affect ESA-listed fin whales.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Fin whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no fin whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the unintentional taking of fin whales incidental to those activities.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 2 would not affect ESA-listed fin whales.

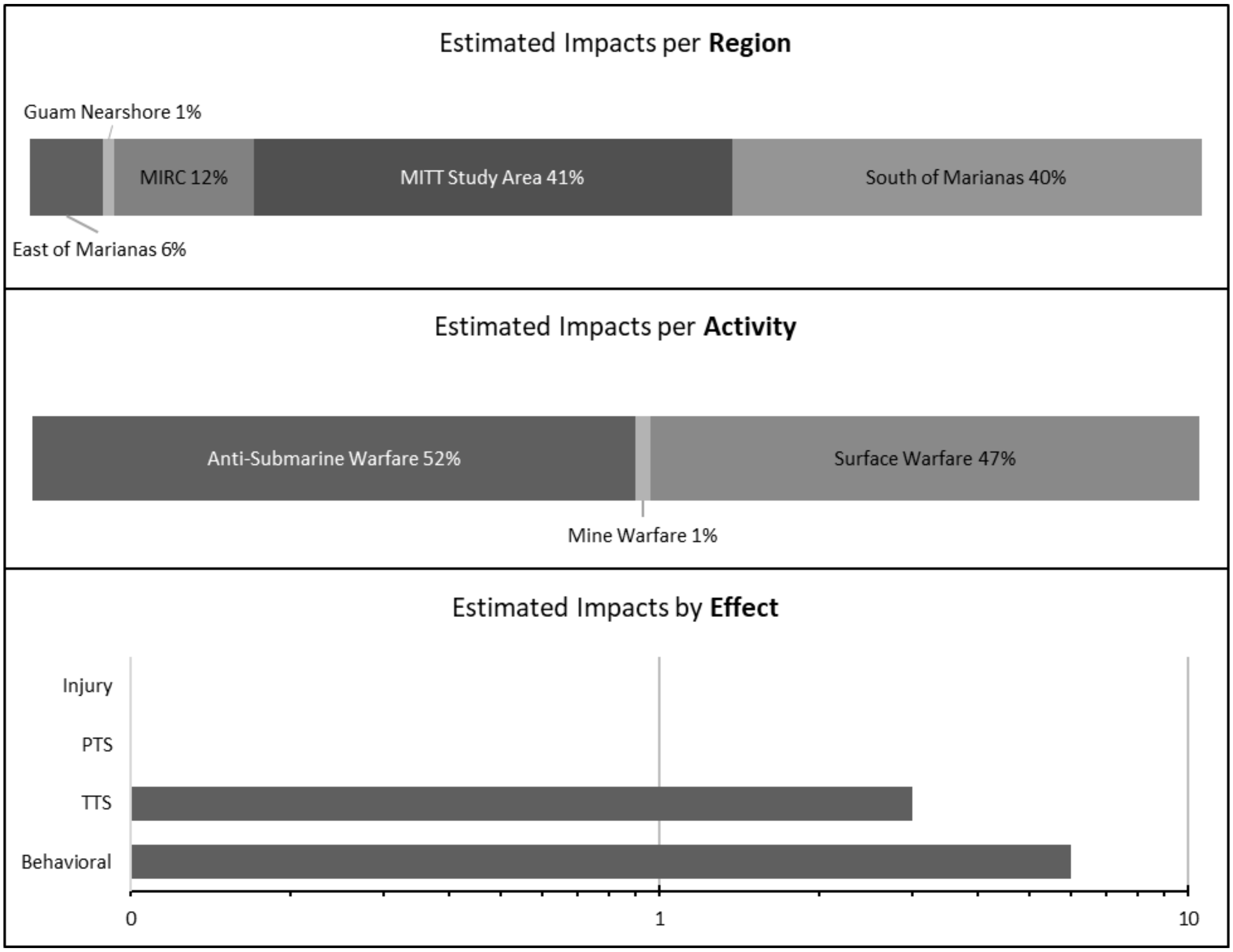
Humpback Whale (Endangered Species Act-Listed)

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Humpback whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS (see Figure 3.4-67 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for mysticetes above, even a few minor to moderate TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of humpback whales incidental to those activities.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 1 may affect ESA-listed humpback whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

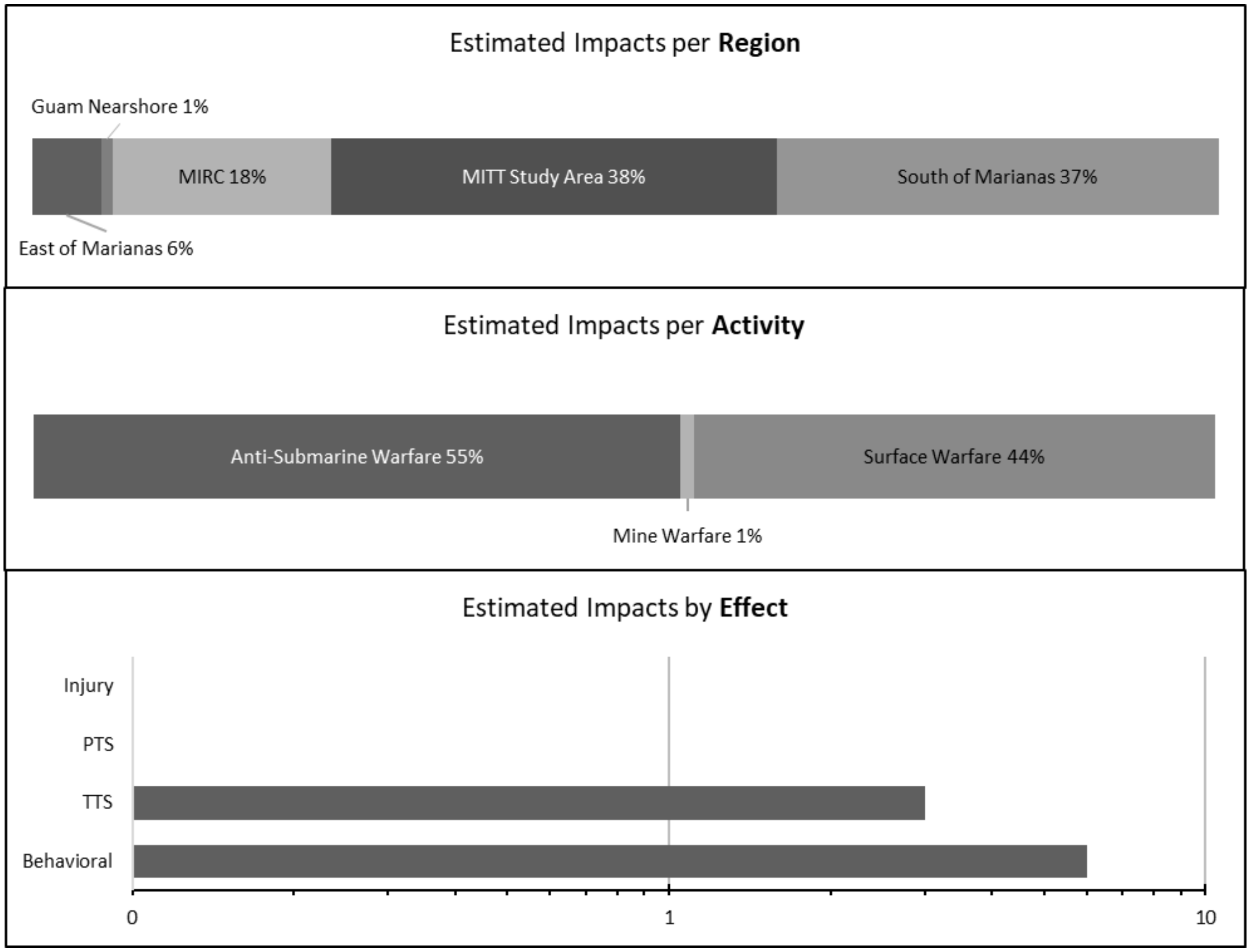
Figure 3.4-67: Humpback Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly in location and number (see Figure 3.4-68) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities. The primary distinction is that explosive use would be consistent year to year under Alternative 2 and the total number of activities would increase slightly compared to Alternative 1.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of humpback whales incidental to those activities.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 2 may affect ESA-listed humpback whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

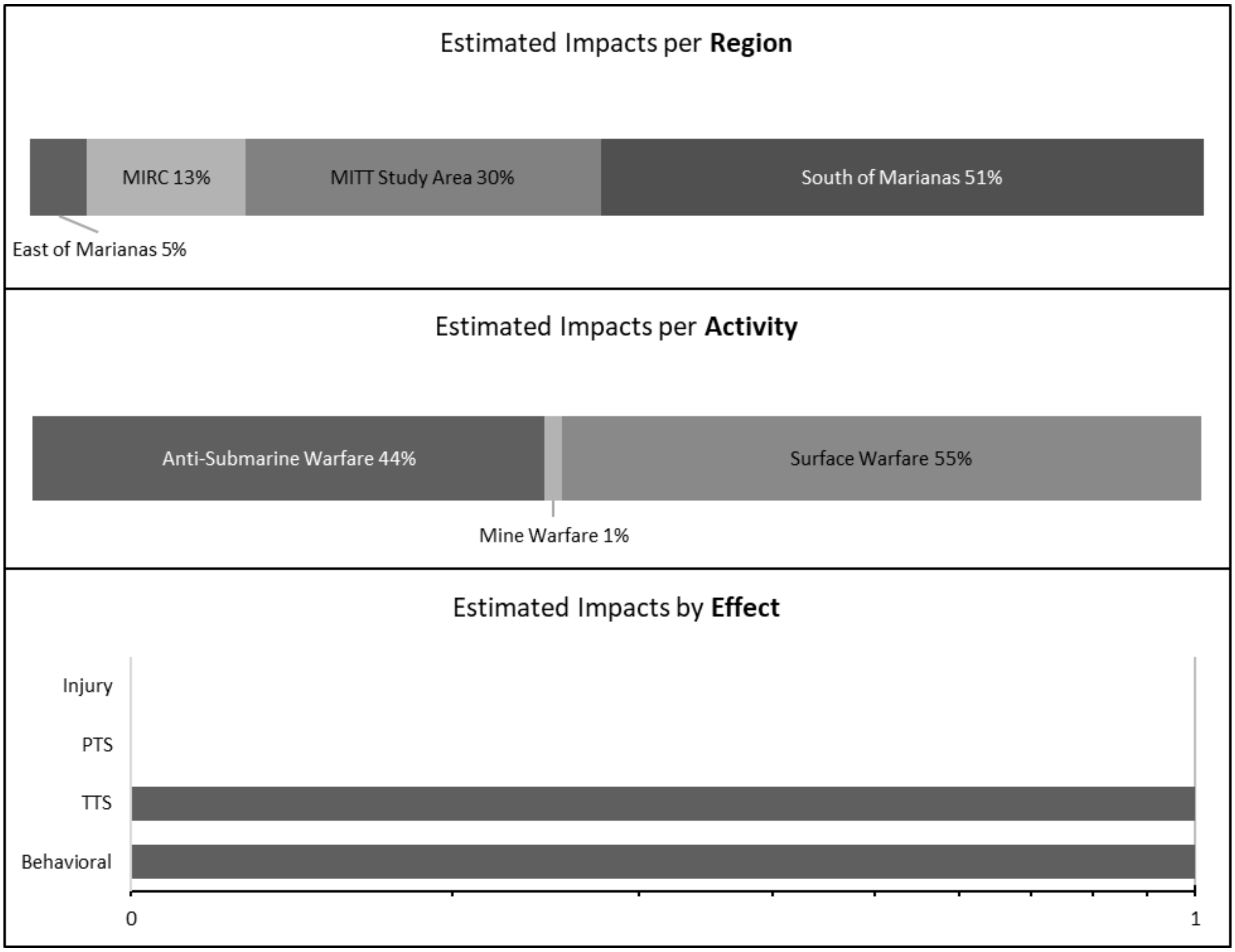
Figure 3.4-68: Humpback Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Minke Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Minke whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS (see Figure 3.4-69 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for mysticetes above, even a few minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of minke whales incidental to those activities.



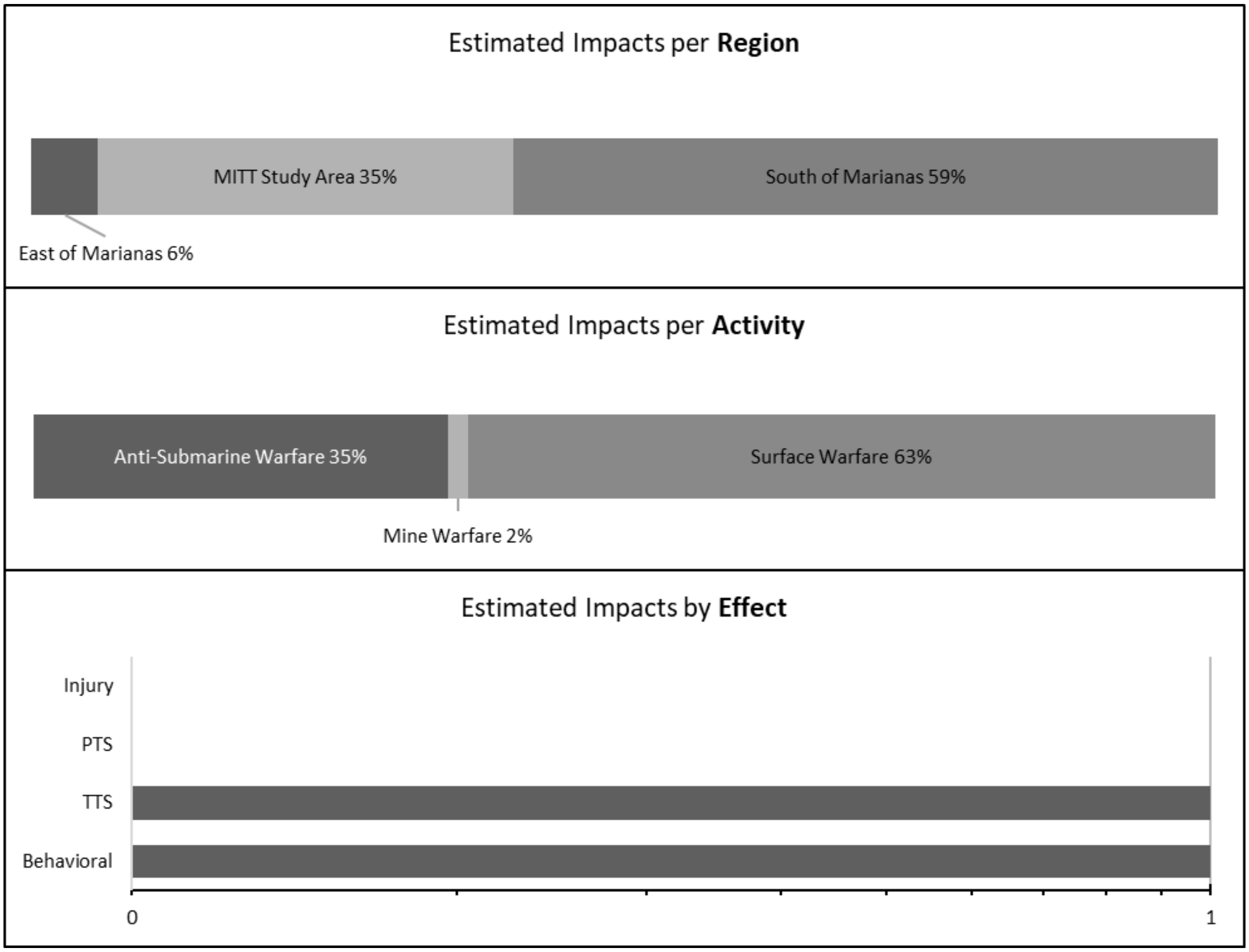
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-69: Minke Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training with explosives would differ slightly in activity and location (see Figure 3.4-70) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities; however, the total number of impacts would remain the same.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of minke whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-70: Minke Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Omura's Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

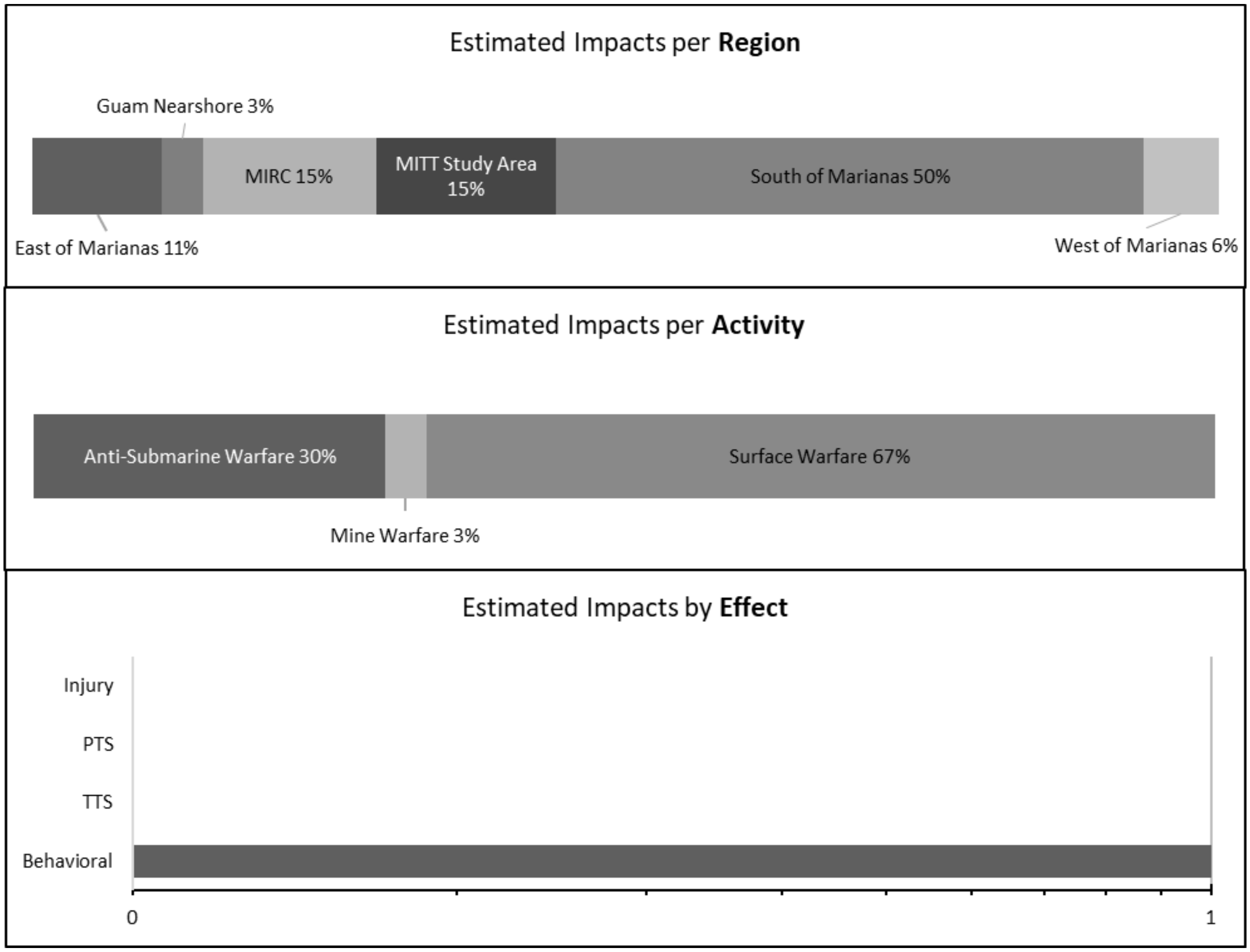
Omura's whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no Omura's whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the unintentional taking of Omura's whales incidental to those activities.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Omura's whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 2, estimates behavioral reactions (see Figure 3.4-71 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for mysticetes above, even a few minor to moderate behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of Omura's whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No TTS, PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-71: Omura's Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

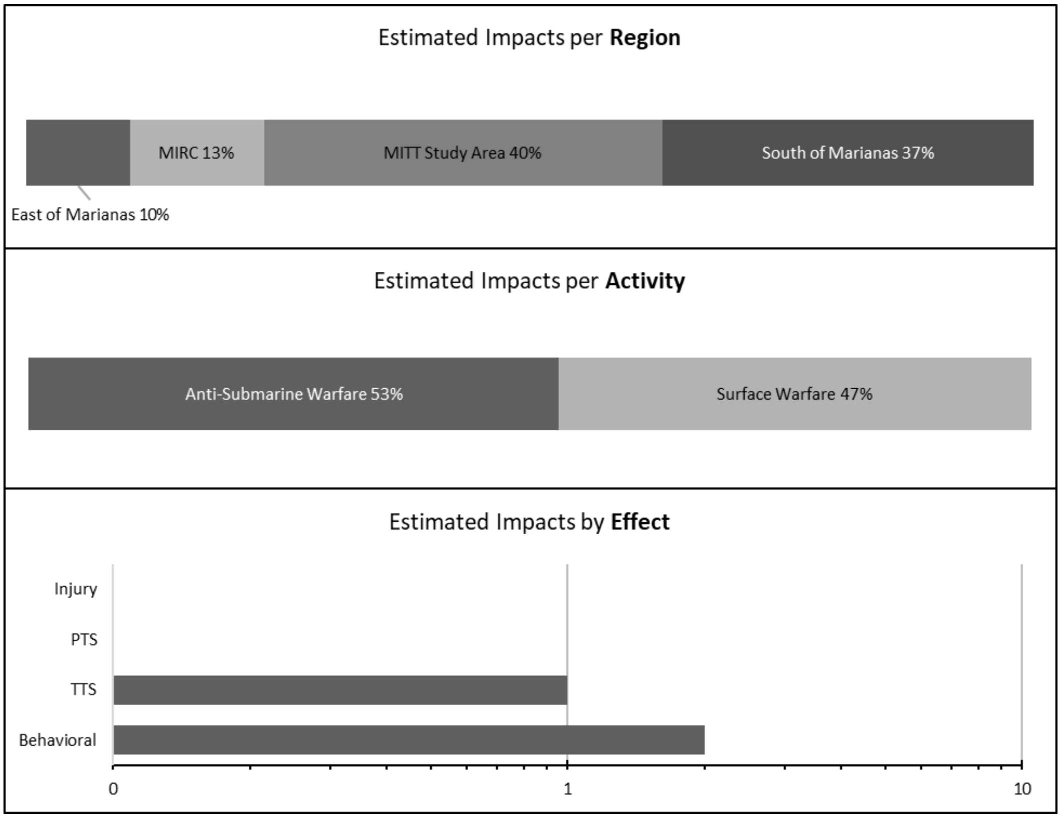
Sei Whale (Endangered Species Act-Listed)

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Sei whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS (see Figure 3.4-72 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for mysticetes above, even a few minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of sei whales incidental to those activities.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 1 may affect ESA-listed sei whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

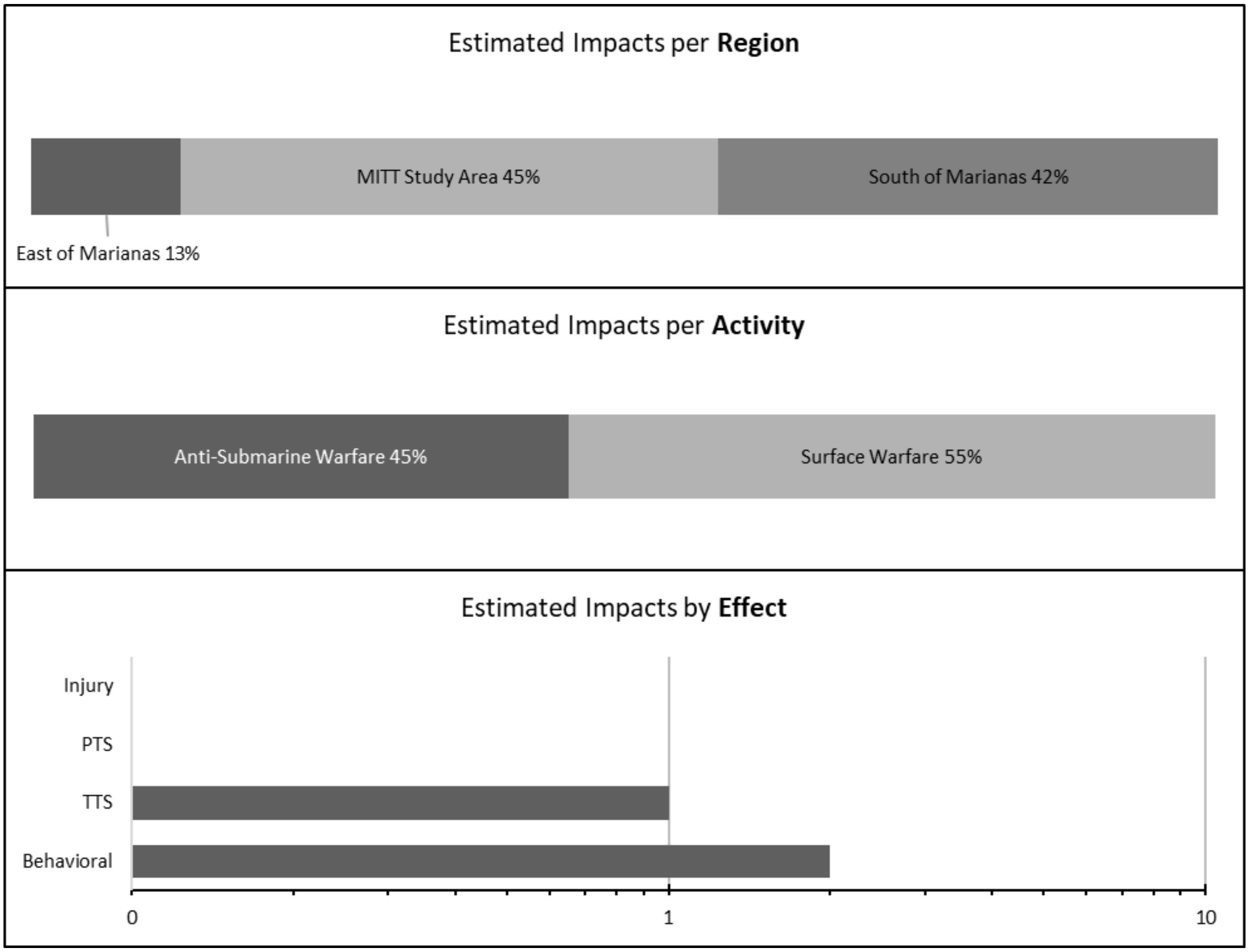
Figure 3.4-72: Sei Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training with explosives would differ slightly in location (see Figure 3.4-73) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities; however, the total number of impacts would remain the same.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of sei whales incidental to those activities.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 2 may affect ESA-listed sei whales.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No TTS, or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-73: Sei Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Odontocetes

Odontocetes may be exposed to sound and energy from explosives associated with training and testing activities throughout the year. Explosions produce sounds that are within the hearing range of odontocetes (see Section 3.4.1.6, Hearing and Vocalization). Potential impacts from explosive energy and sound include non-auditory injury, behavioral reactions, physiological stress, masking and hearing loss. Impact ranges for odontocetes exposed to explosive sound and energy are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives) under mid-frequency cetaceans for most species, and under high-frequency cetaceans for Kogia whales.

Non-auditory injuries to odontocetes, if they did occur, could include anything from mild injuries that are recoverable and are unlikely to have long-term consequences, to more serious injuries, including mortality. It is possible for marine mammals to be injured or killed by an explosion in isolated instances. Animals that did sustain injury could have long-term consequences for that individual. Considering that dolphin species for which these impacts are predicted have populations with tens to hundreds of thousands of animals, removing several animals from the population would be unlikely to have measurable long-term consequences for the species or stocks. As discussed in Section 5.3.3 (Explosive Stressors), the Navy will implement procedural mitigation measures to delay or cease detonations when a marine mammal is sighted in a mitigation zone to avoid or reduce potential explosive impacts.

Odontocetes that do experience a hearing threshold shift from explosive sounds may have reduced ability to detect biologically important sounds (e.g., social vocalizations) until their hearing recovers. Recovery from a hearing threshold shift begins almost immediately after the noise exposure ceases. A threshold shift can take a few minutes to a few days, depending on the severity of the initial shift, to recover. TTS would recover fully and PTS would leave some residual hearing loss. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. Noise from explosions is broadband with most energy below a few hundred Hertz; therefore, any hearing loss from exposure to explosive sounds is likely to be broadband with effects predominantly at lower frequencies. During the period that an odontocete had hearing loss, social calls from conspecifics and sounds from predators such as killer whale vocalizations could be more difficult to detect or interpret, although many of these sounds may be above the frequencies of the threshold shift. Odontocetes use echolocation clicks to find and capture prey. These echolocation clicks and vocalizations are at frequencies above a few kHz, which are less likely to be affected by threshold shift at lower frequencies, and should not affect odontocete's ability to locate prey or rate of feeding.

Research and observations of masking in marine mammals due to impulsive sounds are discussed in Section 3.4.2.2.1.4 (Masking). Explosions introduce low-frequency, broadband sounds into the environment, which could mask hearing thresholds in odontocetes that are nearby, although sounds from explosions last for only a few seconds at most. Also, odontocetes typically communicate, vocalize, and echolocate at higher frequencies that would be less affected by masking noise at lower frequencies such as those produced by an explosion. Masking due to time-isolated detonations would not be significant. Activities that have multiple detonations such as some naval gunfire exercises could create some masking for odontocetes in the area over the short duration of the event. Potential costs to odontocetes from masking are similar to those discussed above for TTS, with the primary difference being that the effects of masking are only present when the sound from the explosion is present within the water and the effect is over the moment the sound has ceased.

Research and observations (see Section 3.4.2.2.1.5, Behavioral Reactions) show that odontocetes do not typically show strong behavioral reactions to impulsive sounds such as explosions. Reactions, if they did occur, would likely be limited to short ranges, within a few kilometers of multiple explosions. Reactions could include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, change in vocalization, or showing no response at all. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Because noise from most activities using explosives is short-term and intermittent, and because detonations usually occur within a small area, behavioral reactions from odontocetes are likely to be short-term and low to moderate severity.

Physiological stress could be caused by injury or hearing loss and could accompany any behavioral reaction as well. Research and observations of physiological stress in marine mammals are discussed in Section 3.4.2.2.1.3 (Physiological Stress). Due to the short-term and intermittent use of explosives, physiological stress is also likely to be short-term and intermittent. Long-term consequences from physiological stress due to the sound of explosives would not be expected.

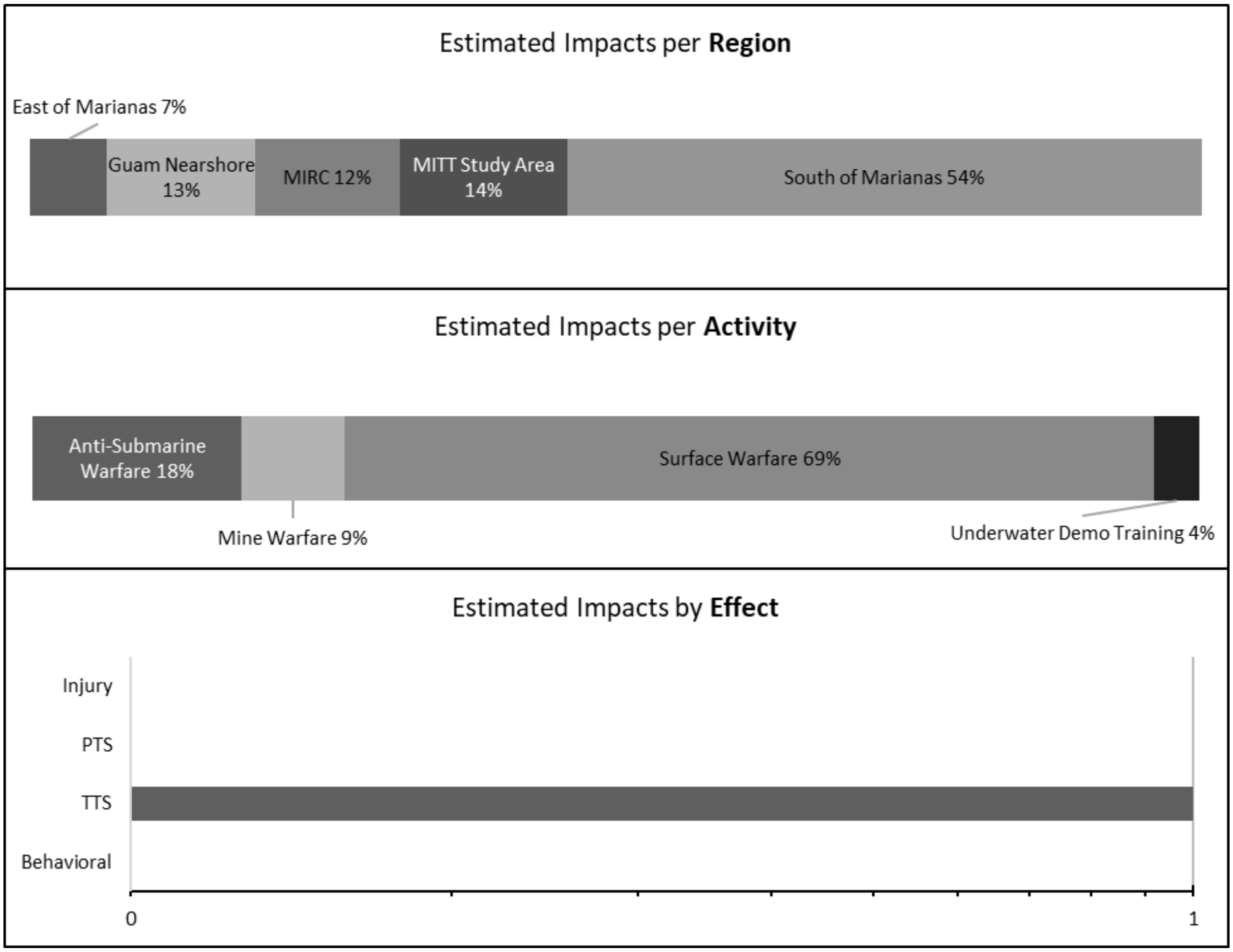
Beaked Whales

Beaked whales within the Study Area include: Blainville's beaked whale, Cuvier's beaked whale, ginkgo-toothed beaked whale, and Longman's beaked whale. Research and observations (Section 3.4.2.2.1.5, Behavioral Reactions) show that beaked whales are sensitive to human disturbance including noise from sonars, although no research on specific reactions to impulsive or explosion noise is available. Odontocetes overall have shown little responsiveness to impulsive sounds although it is likely that beaked whales are more reactive than most other odontocetes. Reactions could include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, change in vocalization, or showing no response at all. Beaked whales on Navy ranges have been observed leaving the area for a few days during sonar training exercises. It is reasonable to expect that animals may leave an area of more intense explosive activity for a few days, however most explosive use during Navy activities is short-duration consisting of only a single or few closely timed explosions (i.e., detonated within a few minutes) with a limited footprint due to a single detonation point. Because noise from most activities using explosives is short-term and intermittent and because detonations usually occur within a small area, behavioral reactions from beaked whales are likely to be short-term and moderate severity.

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

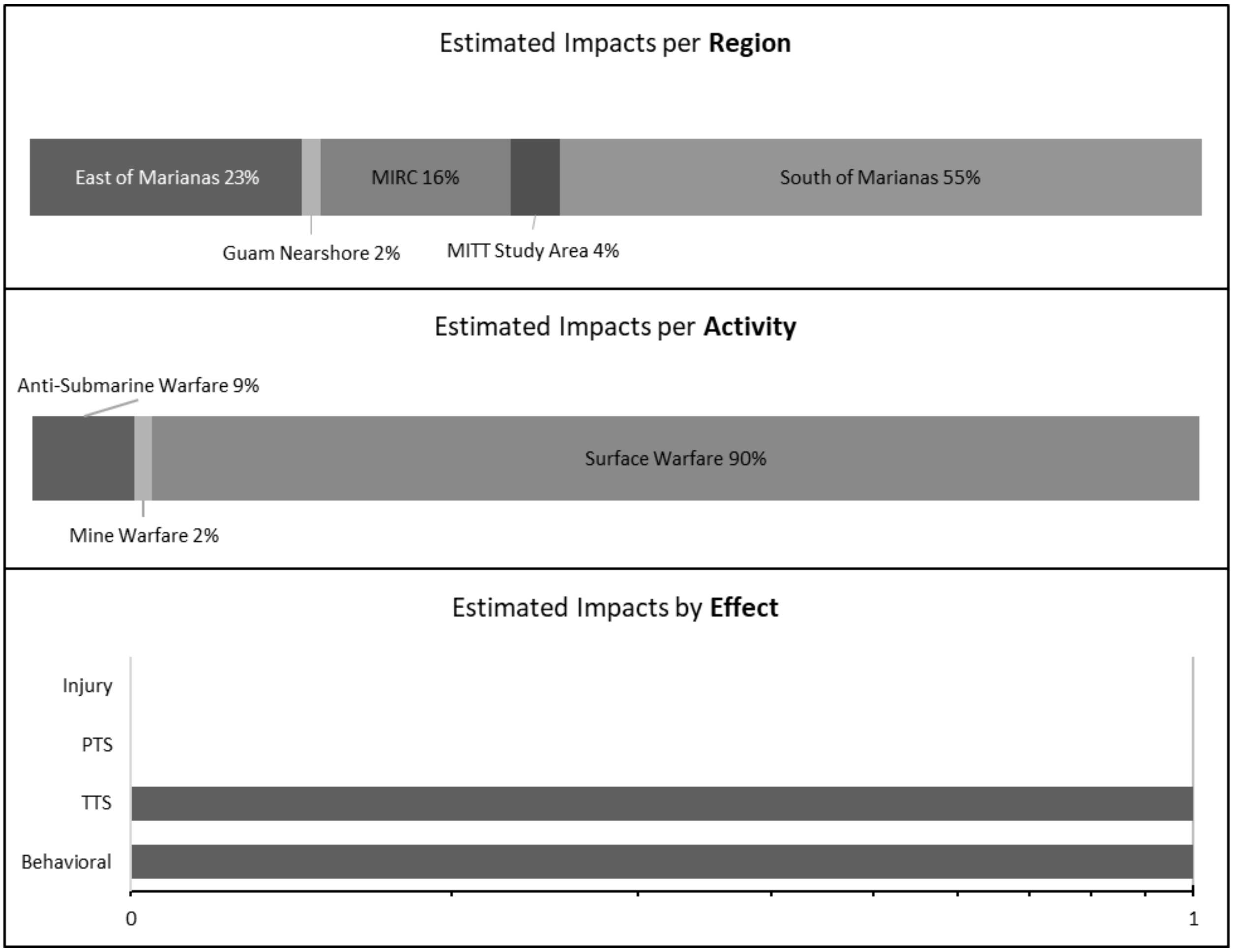
Beaked whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS for only ginkgo-toothed and Longman's beaked whales (see Figure 3.4-74 and Figure 3.4-75, and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for these species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). No impacts are estimated for Blainville's beaked whale or Cuvier's beaked whale. As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of ginkgo-toothed and Longman's beaked whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-74: Ginkgo-Toothed Beaked Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1



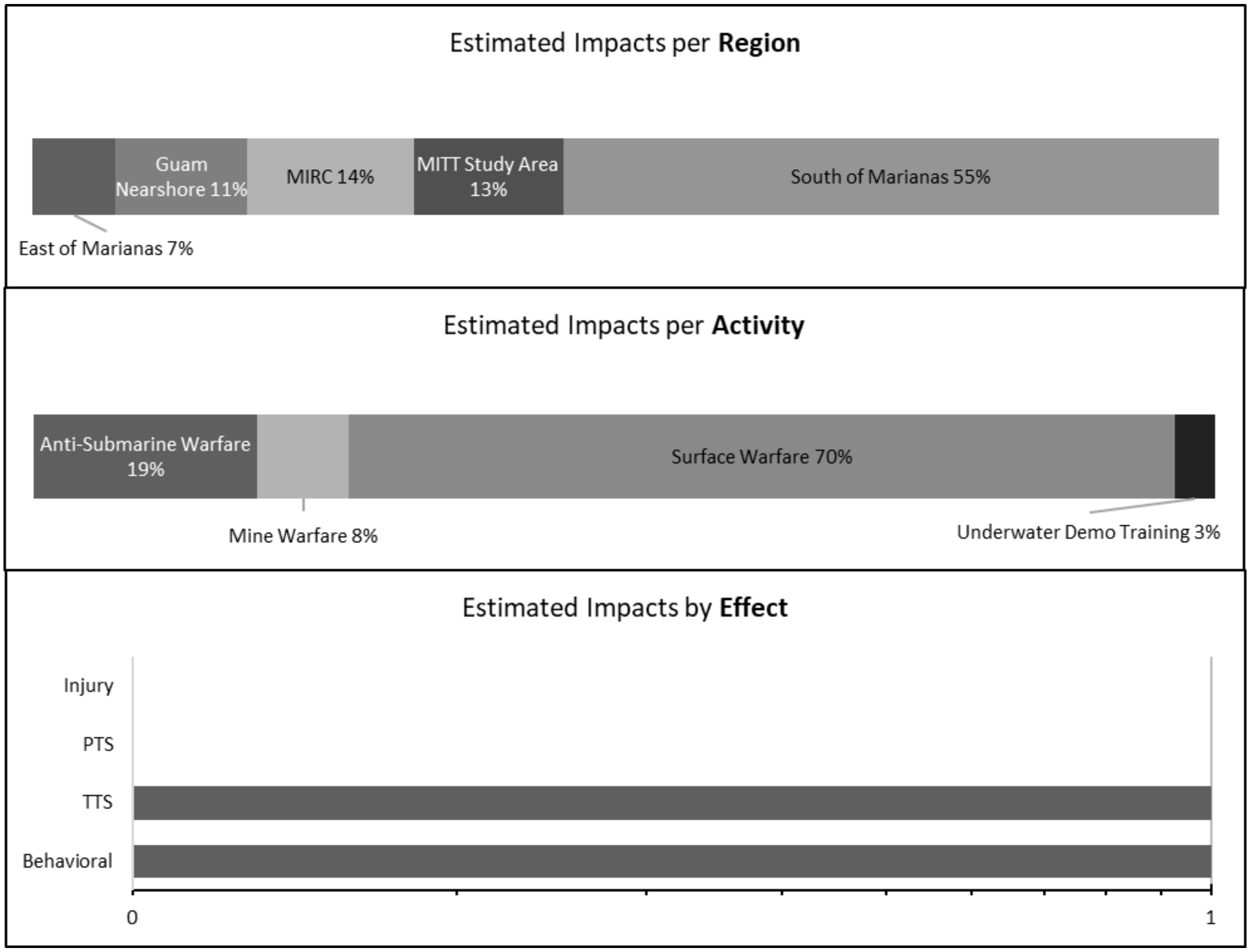
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-75: Longman's Beaked Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

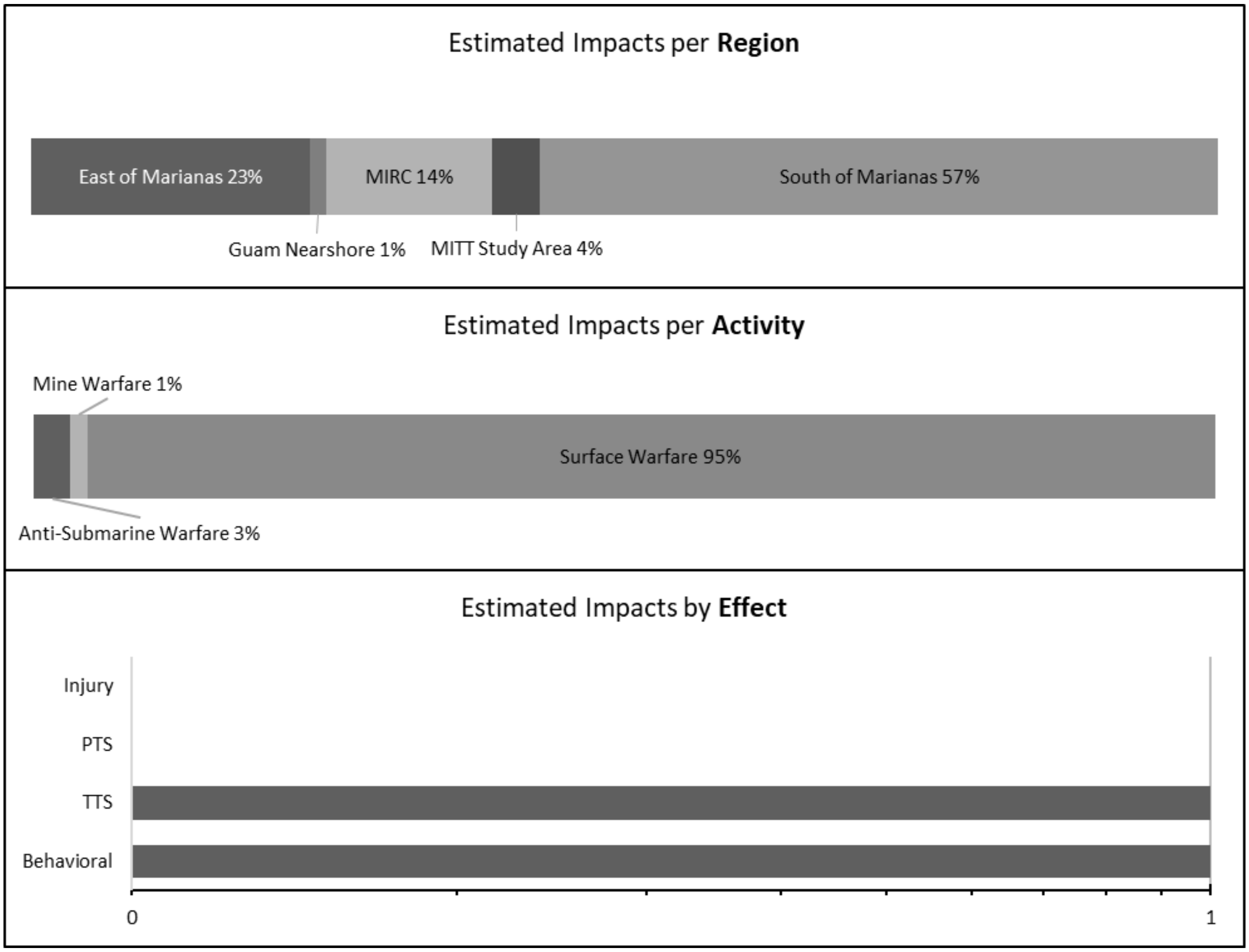
The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS for only ginkgo-toothed and Longman's beaked whales. Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly in location (see Figure 3.4-76 and Figure 3.4-77) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities; however, the total number of impacts would remain the same.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of ginkgo-toothed and Longman's beaked whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-76: Ginkgo-Toothed Beaked Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-77: Longman's Beaked Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Common Bottlenose Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Bottlenose dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no bottlenose dolphins would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the unintentional taking of bottlenose dolphins incidental to those activities.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Bottlenose dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no bottlenose dolphins would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the unintentional taking of bottlenose dolphins incidental to those activities.

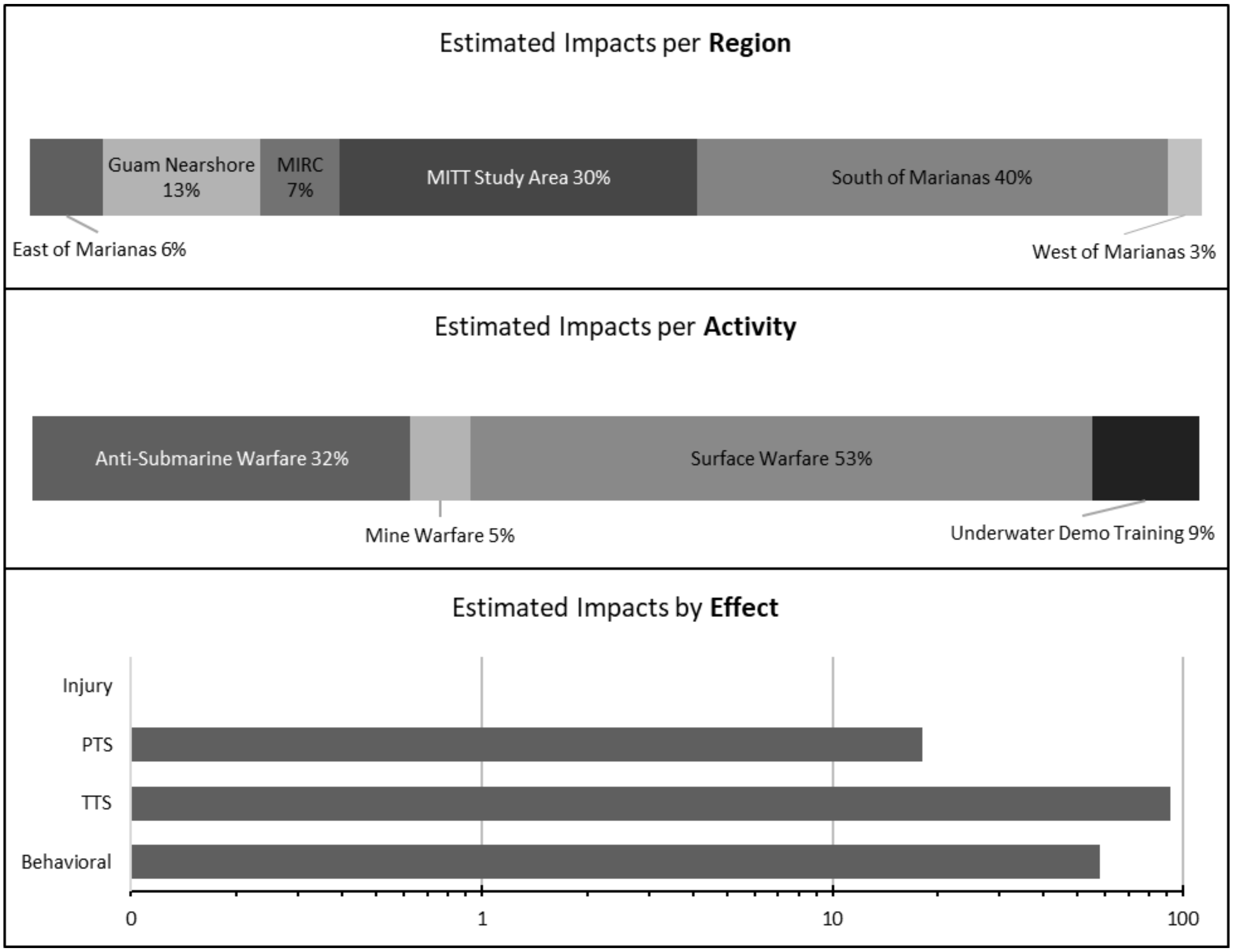
Kogia Whales

Kogia whales include two species that are often difficult to distinguish from one another: dwarf sperm whales and pygmy sperm whales; however, impacts to the populations of dwarf and pygmy sperm whales are modeled separately. TTS and PTS thresholds for high-frequency cetaceans, such as Kogia whales are lower than for all other marine mammals, which leads to a higher number of estimated hearing loss impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans).

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

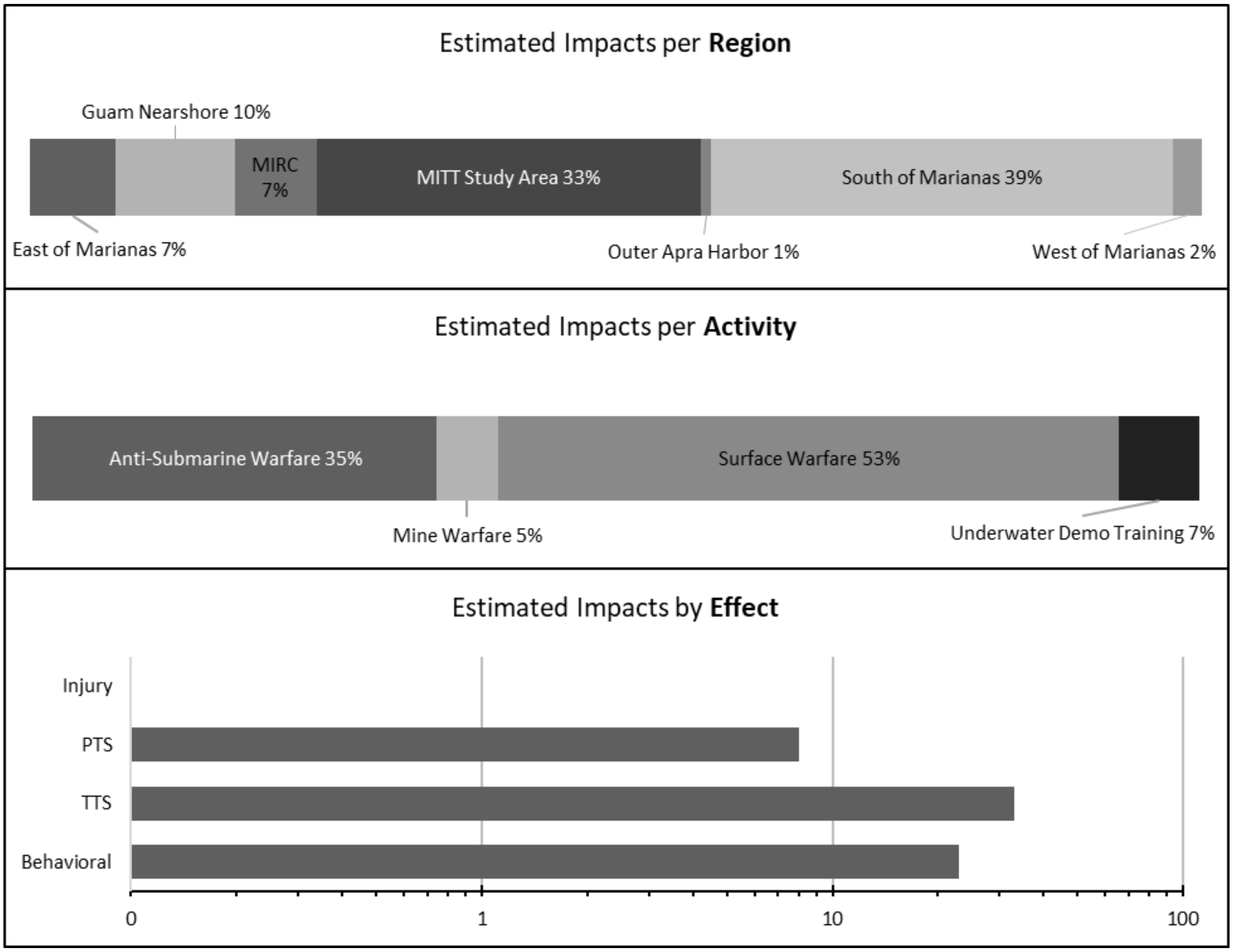
Kogia whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions, TTS, and PTS (see Figure 3.4-78 through Figure 3.4-79, and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for these species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of dwarf and pygmy sperm whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No injuries (non-auditory) are estimated for this species.
(2) MIRC = Mariana Islands Range Complex

Figure 3.4-78: Dwarf Sperm Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1



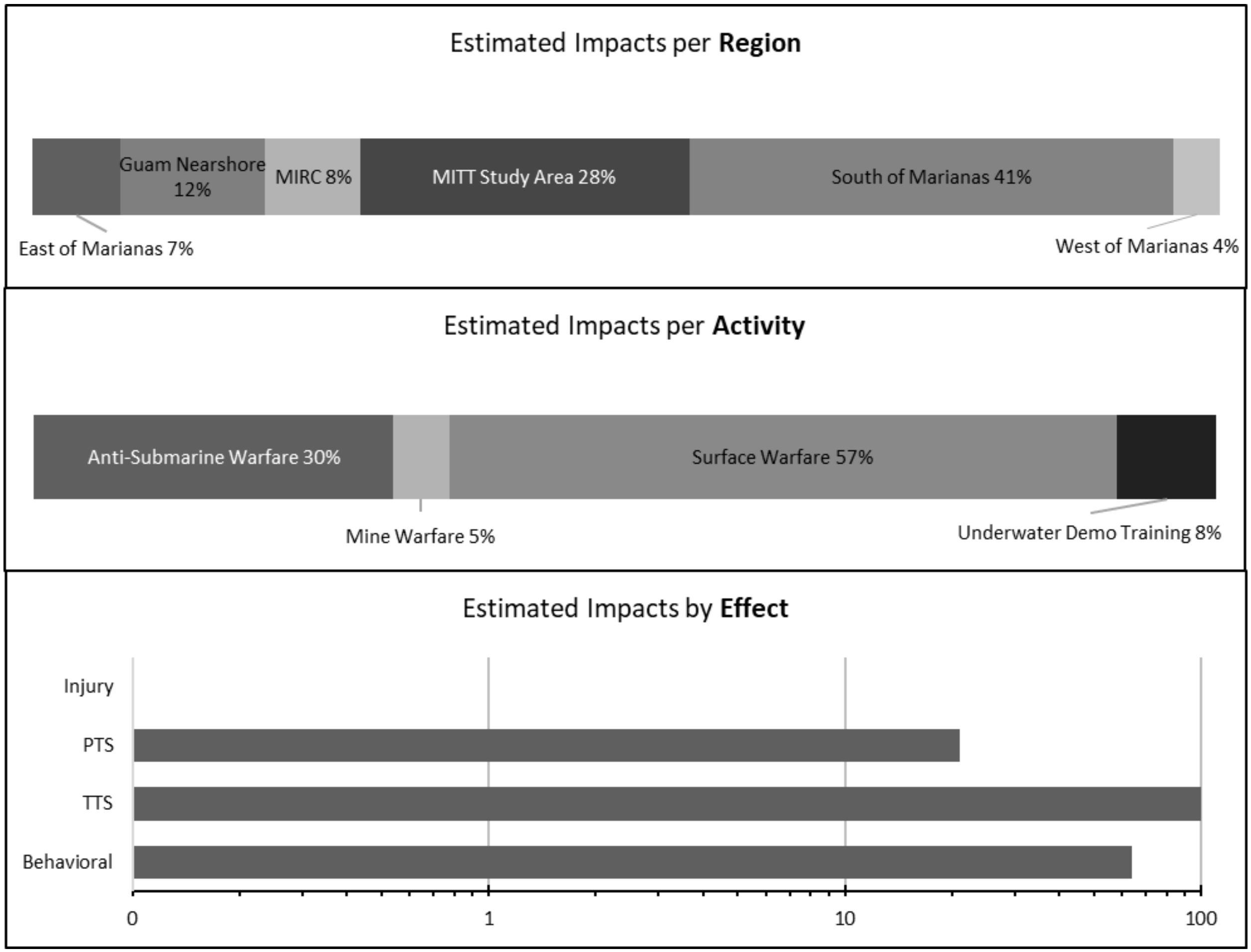
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-79: Pygmy Sperm Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

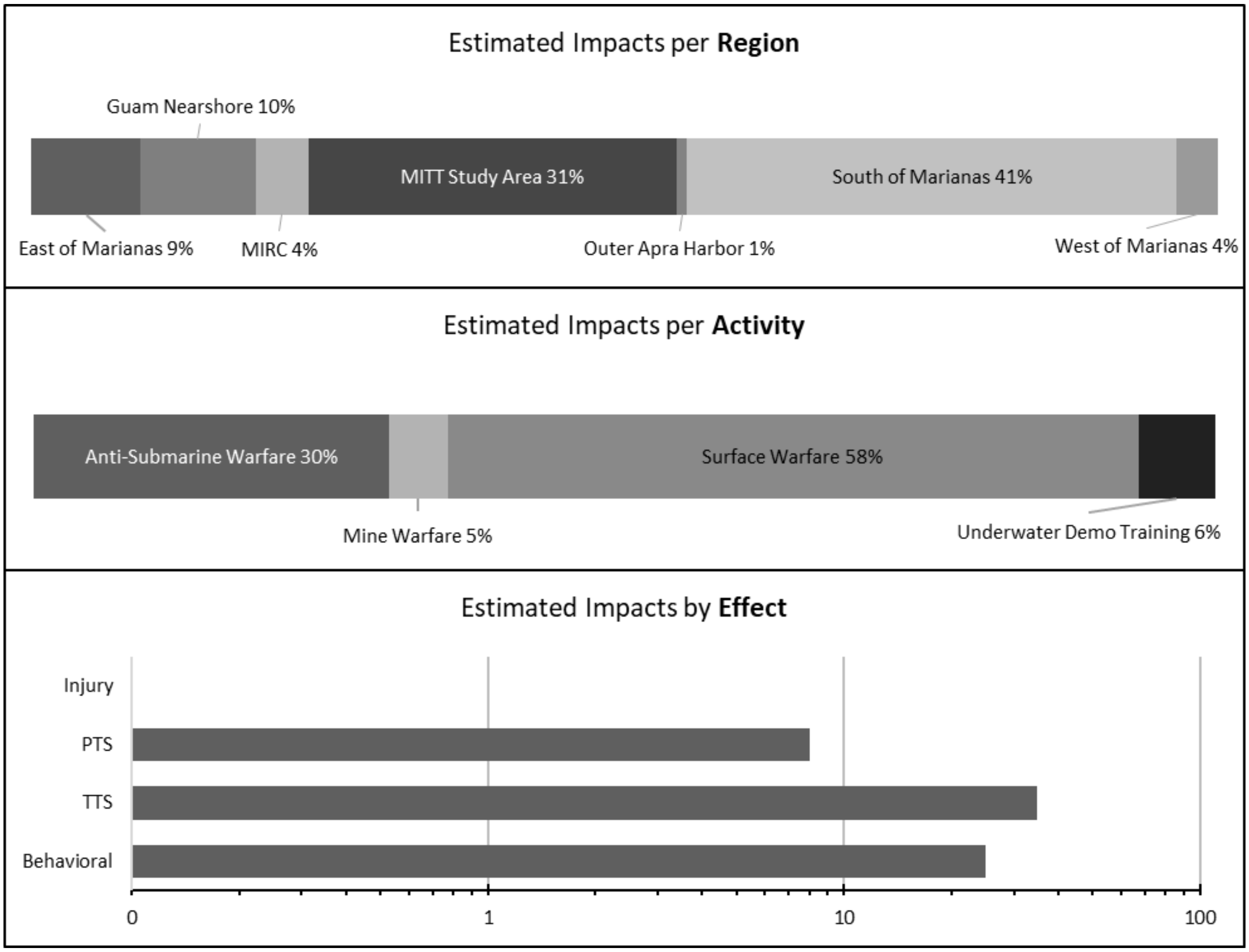
Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly (see Figure 3.4-80 and Figure 3.4-81) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of dwarf and pygmy sperm whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-80: Dwarf Sperm Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-81: Pygmy Sperm Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

False Killer Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

False killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no false killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the unintentional taking of false killer whales incidental to those activities.

Impacts from Explosives Under Alternative 2 for Training Activities

False killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no false killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

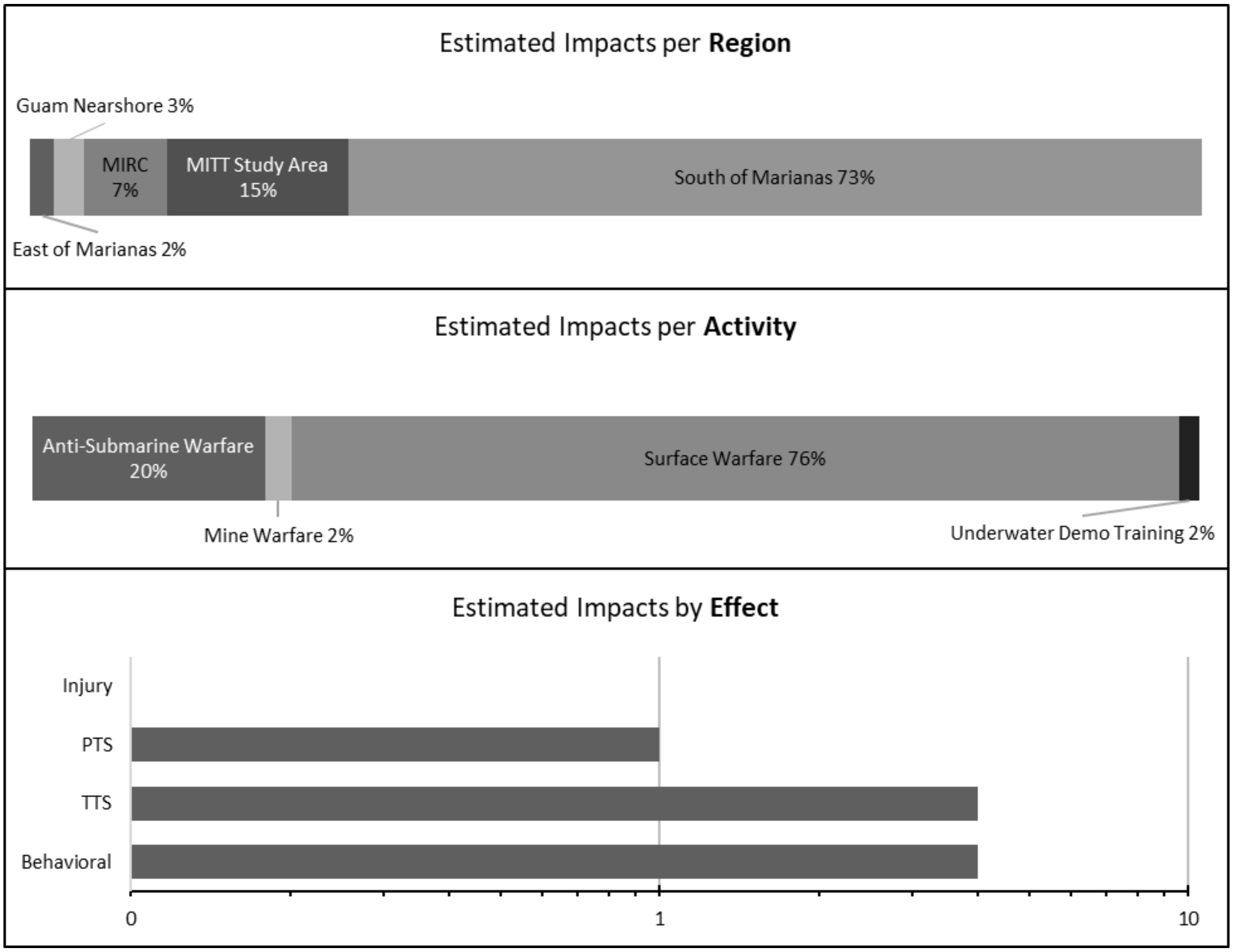
Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the unintentional taking of false killer whales incidental to those activities.

Fraser's Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Fraser's dolphin may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 1, estimates behavioral reaction, TTS, and PTS (see Figure 3.4-82 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of Fraser's dolphins incidental to those activities.



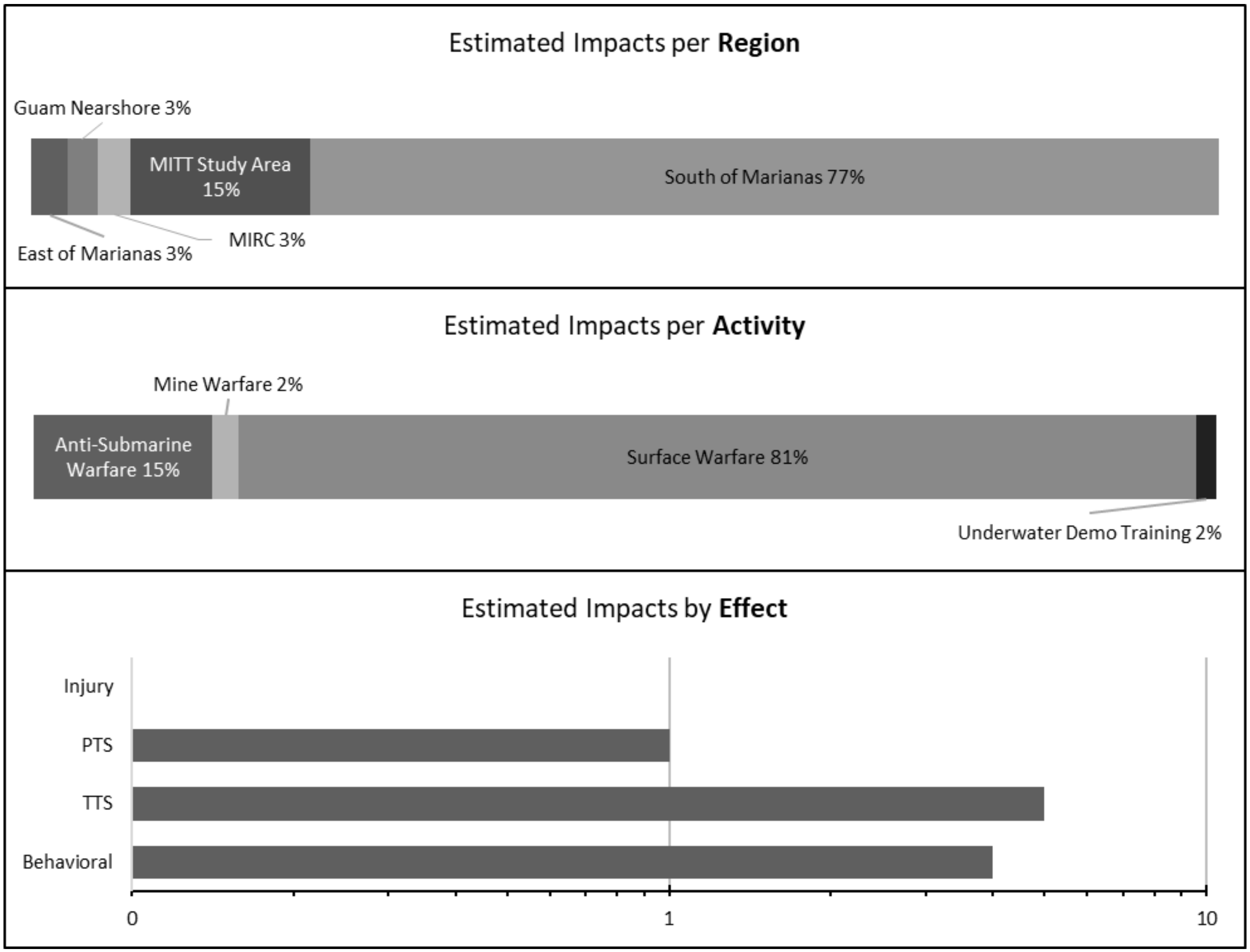
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-82: Fraser's Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would increase slightly (see Figure 3.4-83) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of Fraser's dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-83: Fraser's Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Killer Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the unintentional taking of killer whales incidental to those activities.

Impacts from Explosives Under Alternative 2 for Training Activities

Killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

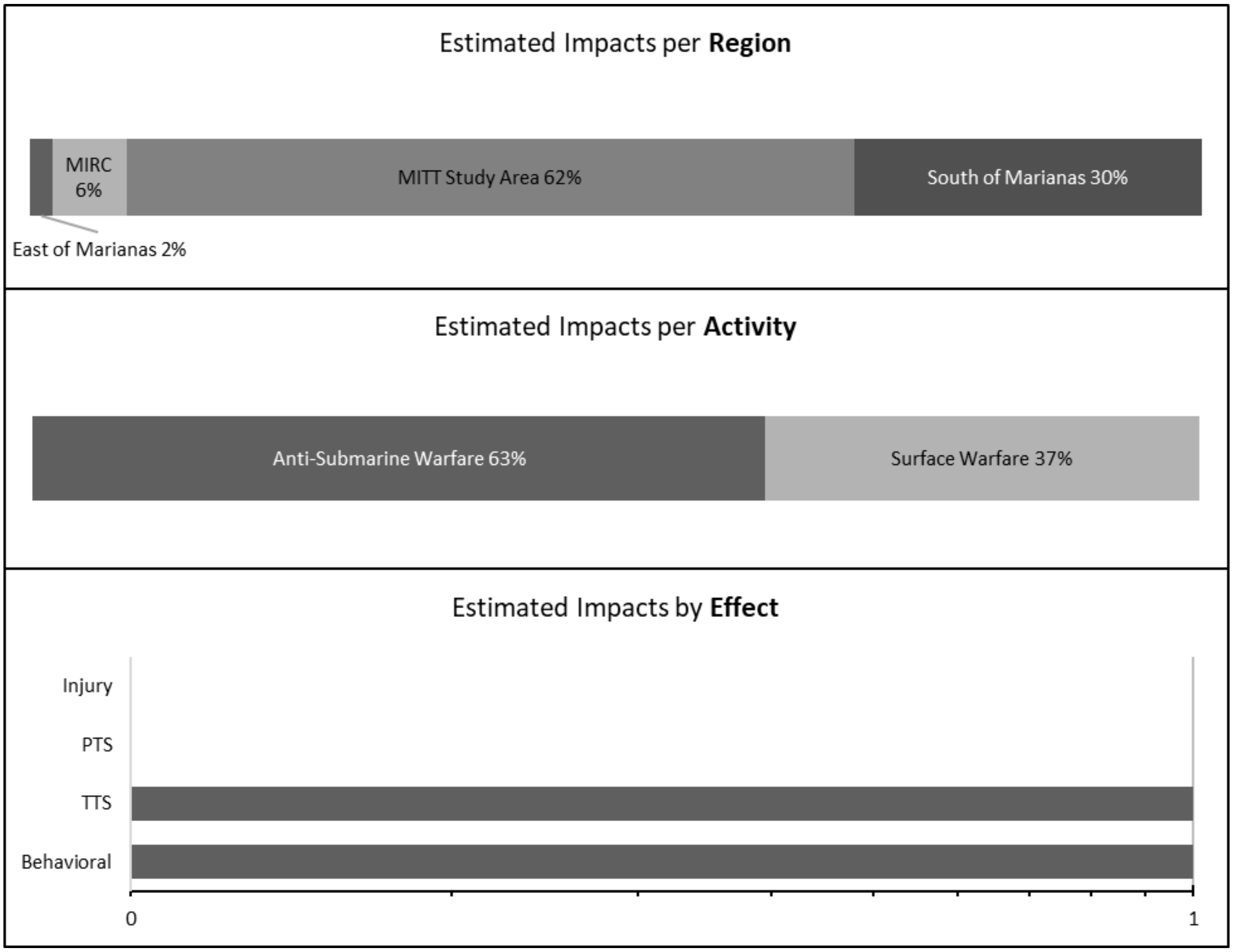
Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the unintentional taking of killer whales incidental to those activities.

Melon-Headed Whale

Impacts from Explosives Under Alternative 1 for Training Activities

Melon-headed whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 1, estimates behavioral reaction and TTS (see Figure 3.4-84 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of melon-headed whales incidental to those activities.



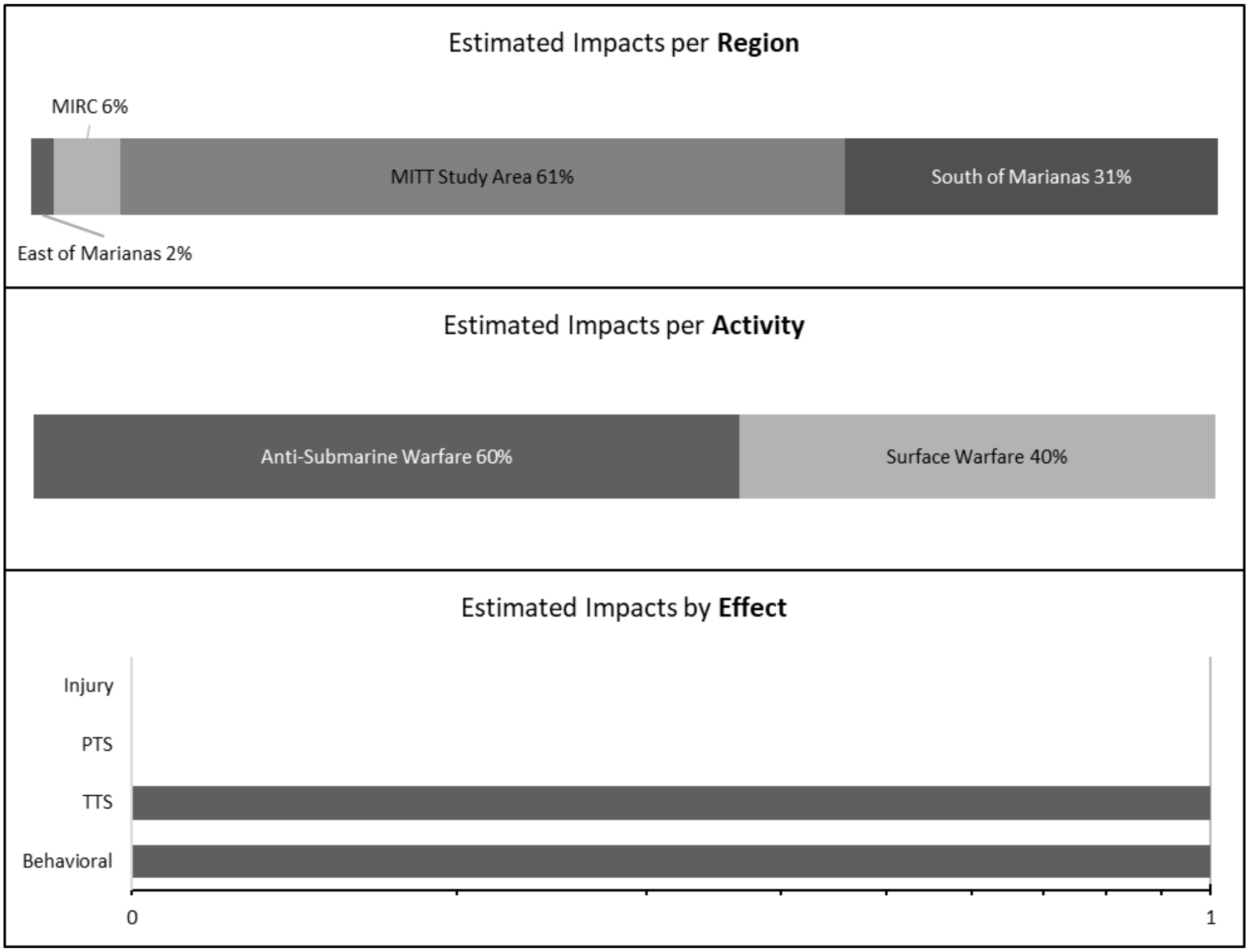
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-84: Melon-Headed Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly by activity and location (see Figure 3.4-85) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities; however, the total number of impacts would remain the same.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of melon-headed whales incidental to those activities.


Estimated Impacts per **Region**

Estimated Impacts per **Activity**

Estimated Impacts by **Effect**

Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No impacts are estimated for training activities. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

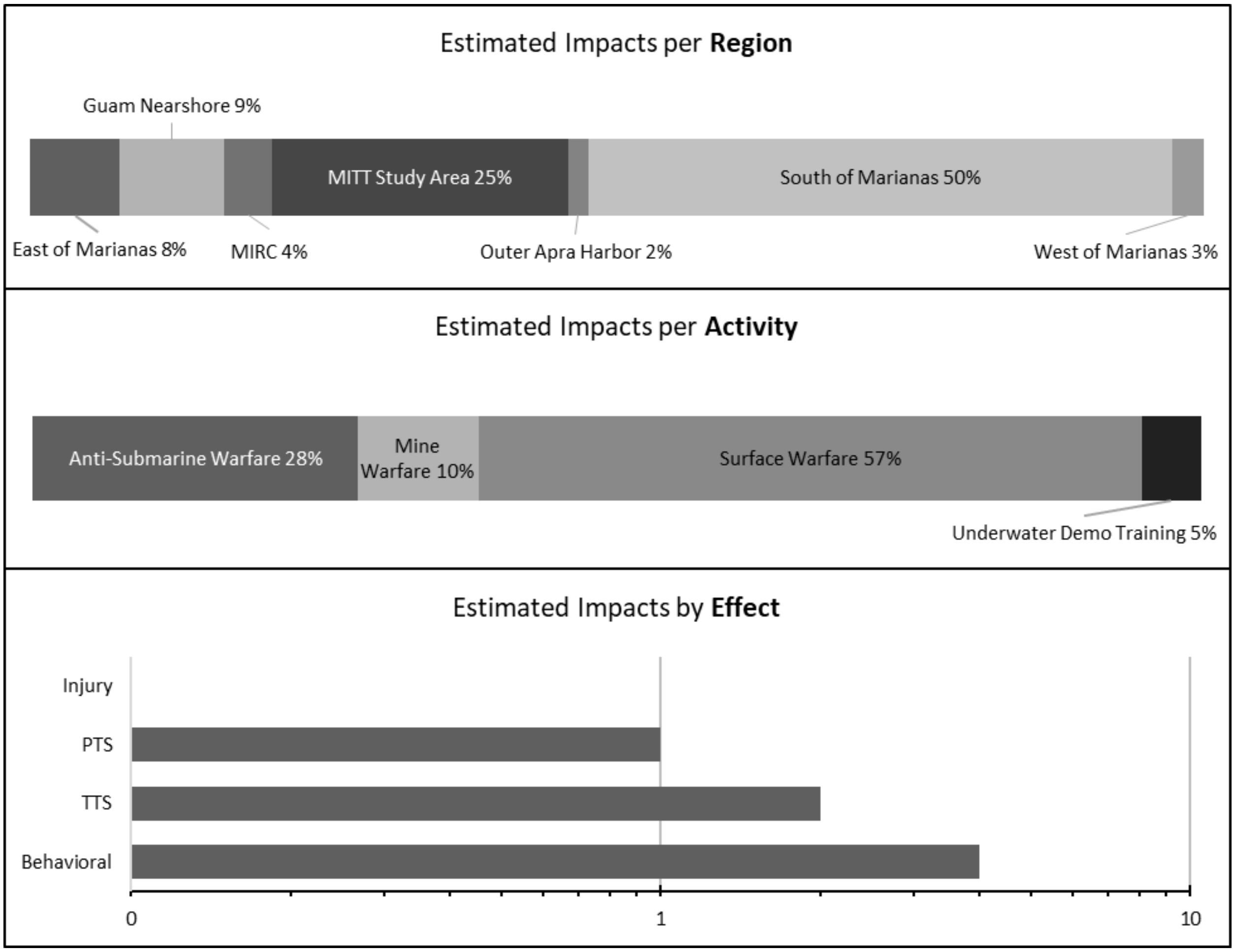
Figure 3.4-85: Melon-Headed Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Pantropical Spotted Dolphin

<u>Impacts from Explosives Under Alternative 1 for Training and Testing Activities</u>

Pantropical spotted dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions, TTS and PTS (see Figure 3.4-86 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS could reduce an animal’s ability to detect biologically important sounds; however, as discussed above, a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that pantropical spotted dolphins rely upon. Nevertheless, PTS could have minor long-term consequences for individuals. This minor consequence for an individual is unlikely to have any long-term consequences for the species. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of pantropical spotted dolphins incidental to those activities.



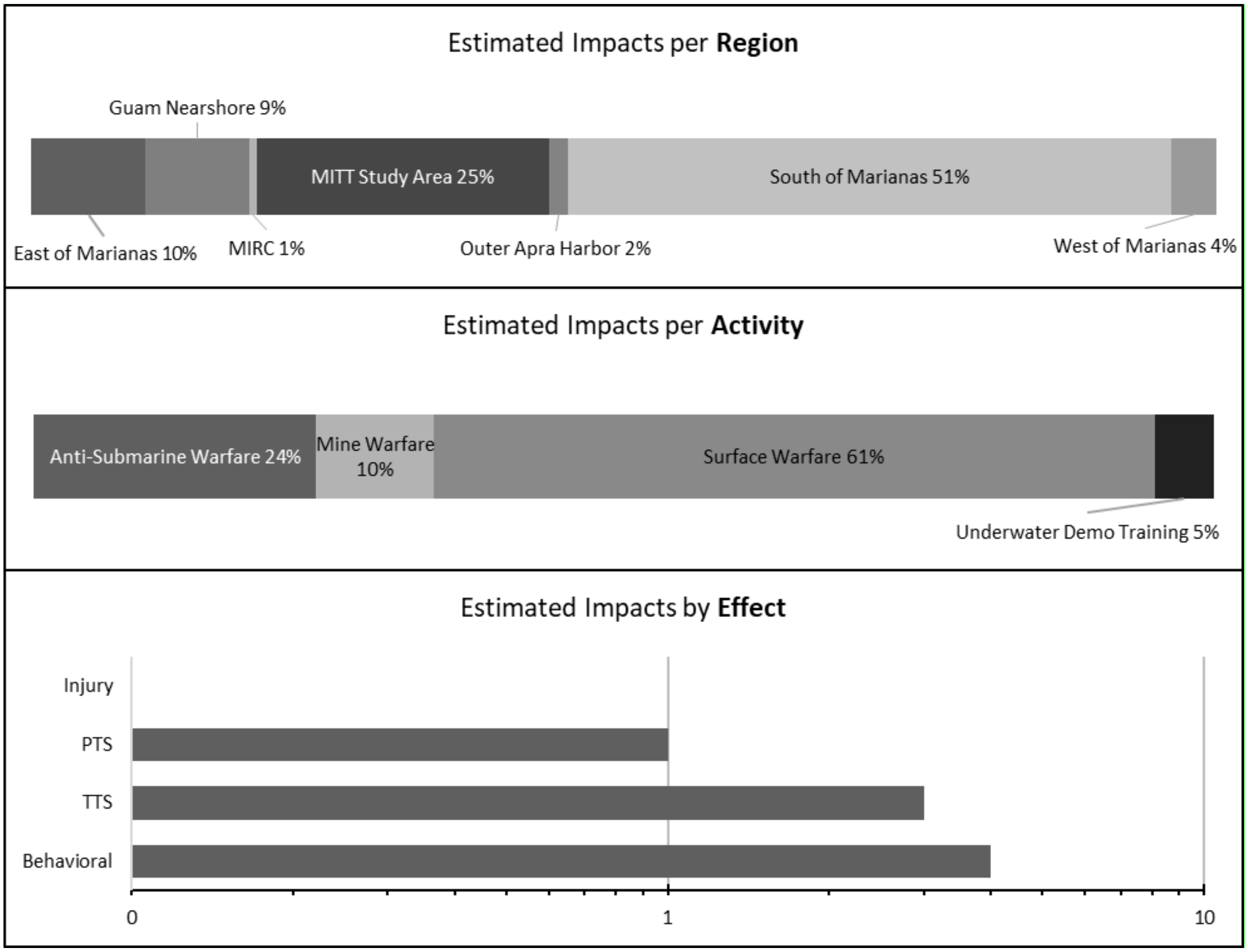
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-86: Pantropical Spotted Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would increase slightly (see Figure 3.4-87) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of pantropical spotted dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-87: Pantropical Spotted Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Pygmy Killer Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Pygmy killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no pygmy killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the unintentional taking of pygmy killer whales incidental to those activities.

Impacts from Explosives Under Alternative 2 for Training Activities

Pygmy killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no pygmy killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

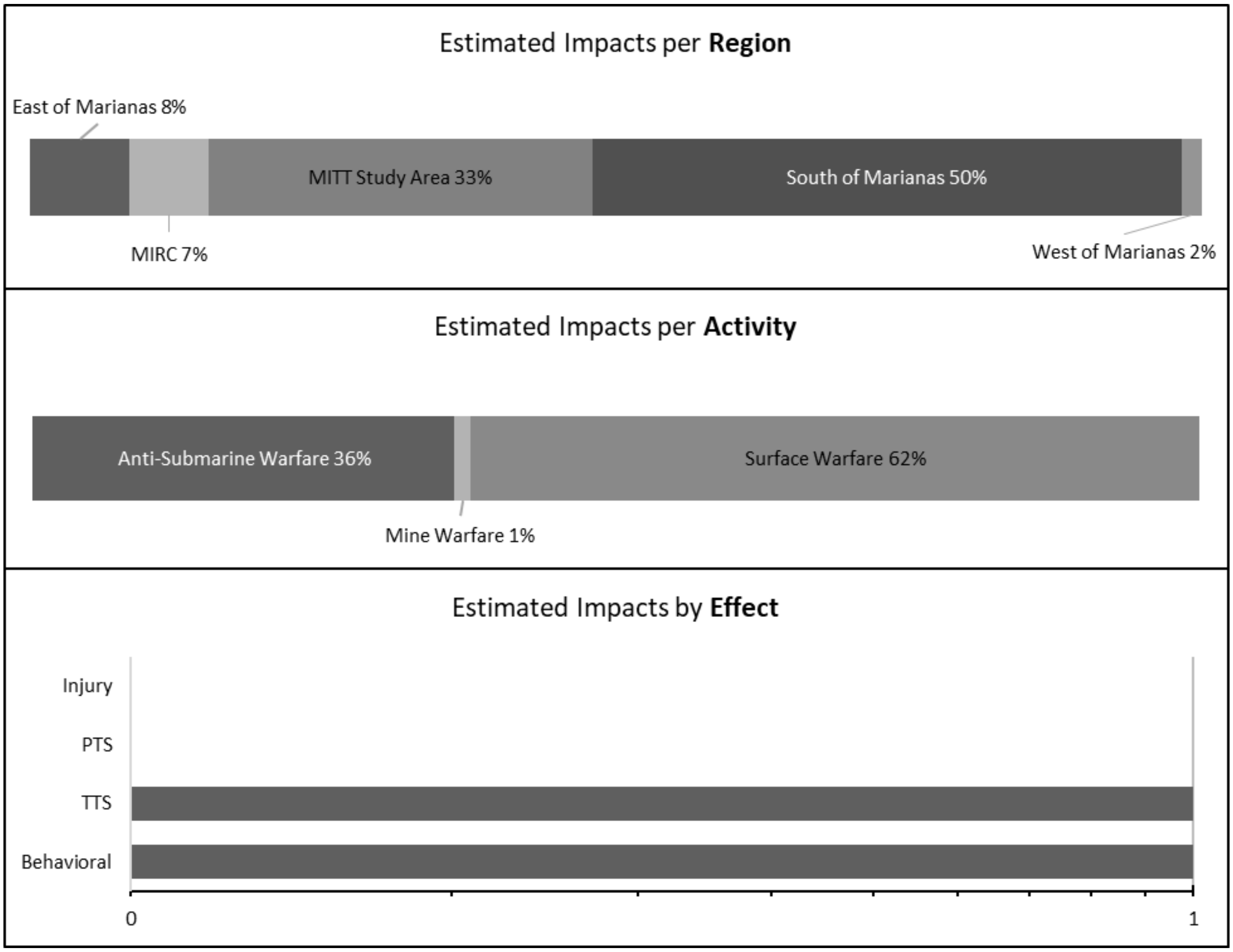
Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the unintentional taking of pygmy killer whales incidental to those activities.

Risso's Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Risso's dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 1, estimates a behavioral reaction and TTS (see Figure 3.4-88 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of Risso's dolphins incidental to those activities.



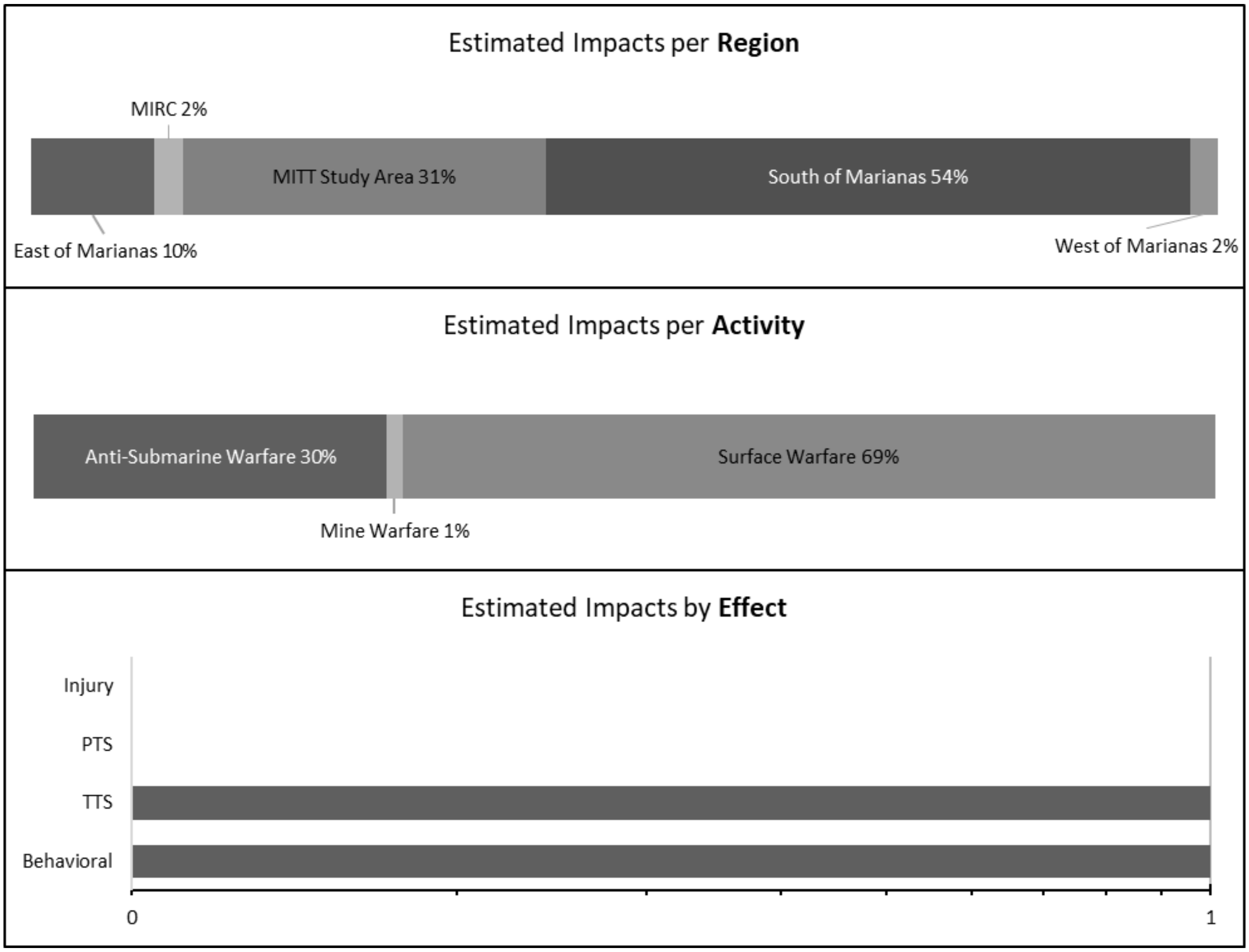
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-88: Risso's Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly (see Figure 3.4-89) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of Risso's dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-89: Risso's Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Rough-Toothed Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Rough-toothed dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no rough-toothed dolphins would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the unintentional taking of rough-toothed dolphins incidental to those activities.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Rough-toothed dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no rough-toothed dolphins would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the unintentional taking of rough-toothed dolphins incidental to those activities.

Short-Finned Pilot Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

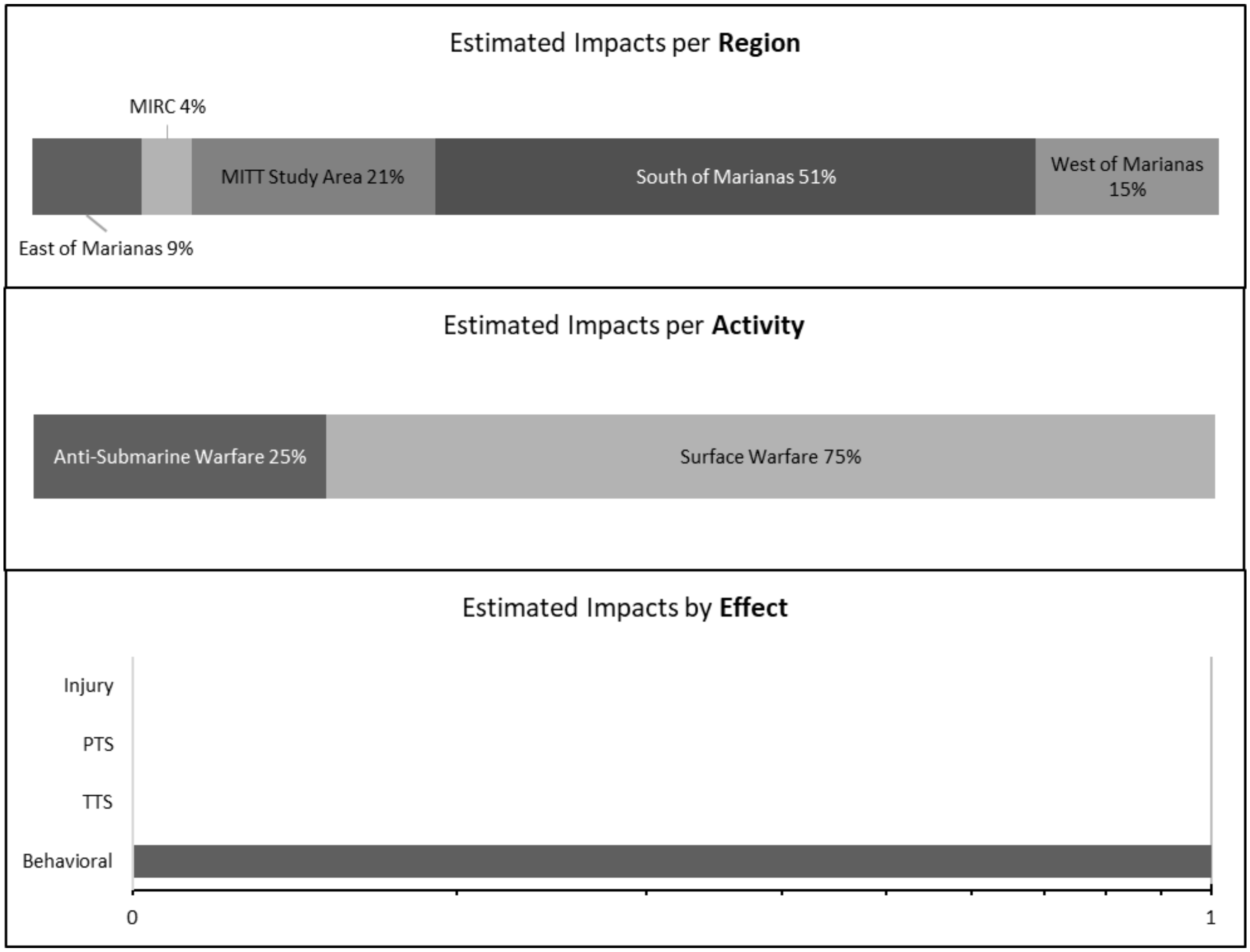
Short-finned pilot whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no short-finned pilot whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the unintentional taking of short-finned pilot whales incidental to those activities.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Short-finned pilot whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 2, estimates behavioral reaction (see Figure 3.4-90 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of short-finned pilot whales incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No TTS, PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-90: Short-Finned Pilot Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Sperm Whale (Endangered Species Act-Listed)

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Sperm whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no sperm whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the unintentional taking of sperm whales incidental to those activities.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 1 would not affect ESA-listed sperm whales.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Sperm whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no sperm whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the unintentional taking of sperm whales incidental to those activities.

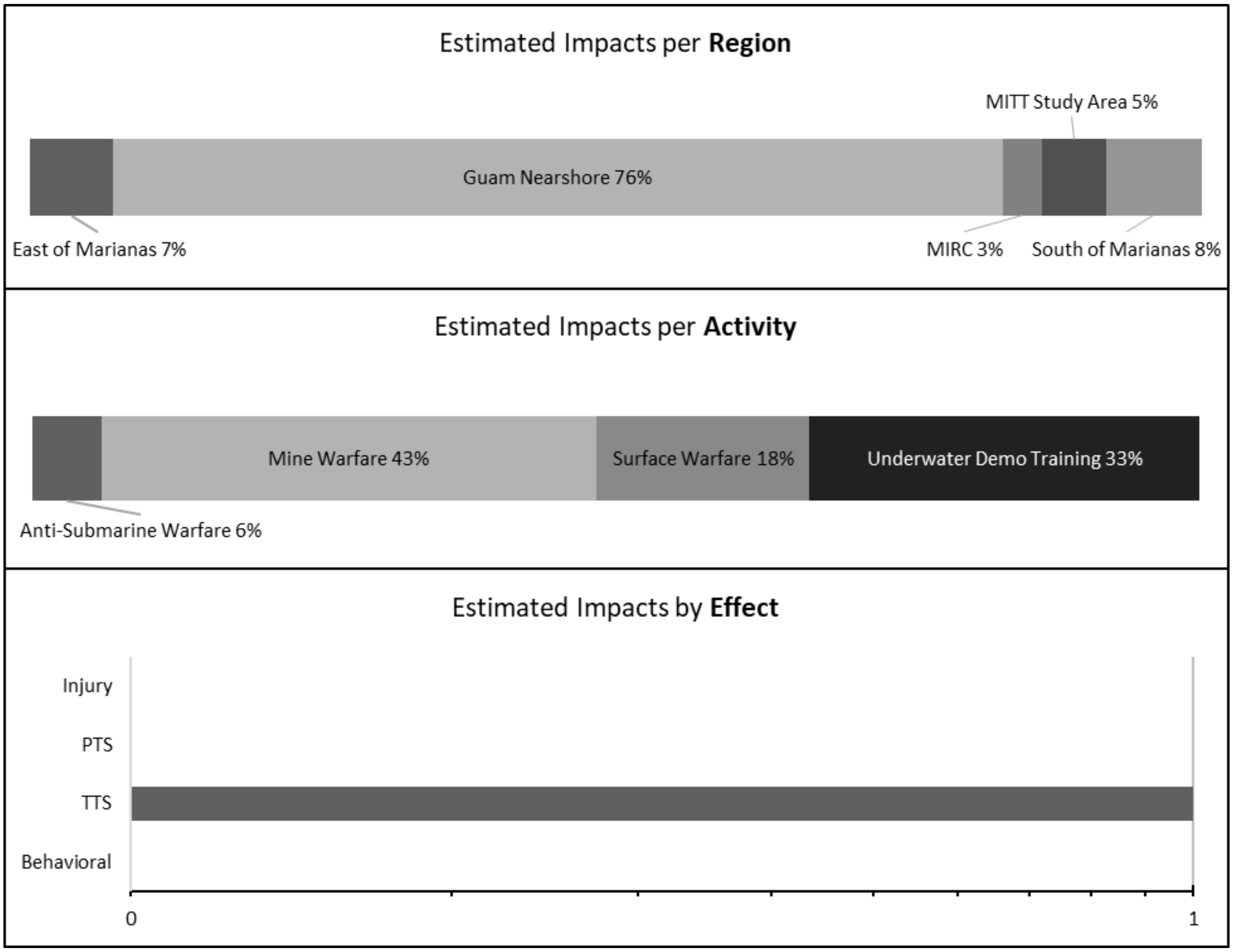
Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 2 would not affect ESA-listed sperm whales.

Spinner Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Spinner dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 1, estimates TTS (see Figure 3.4-91 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of spinner dolphins incidental to those activities.



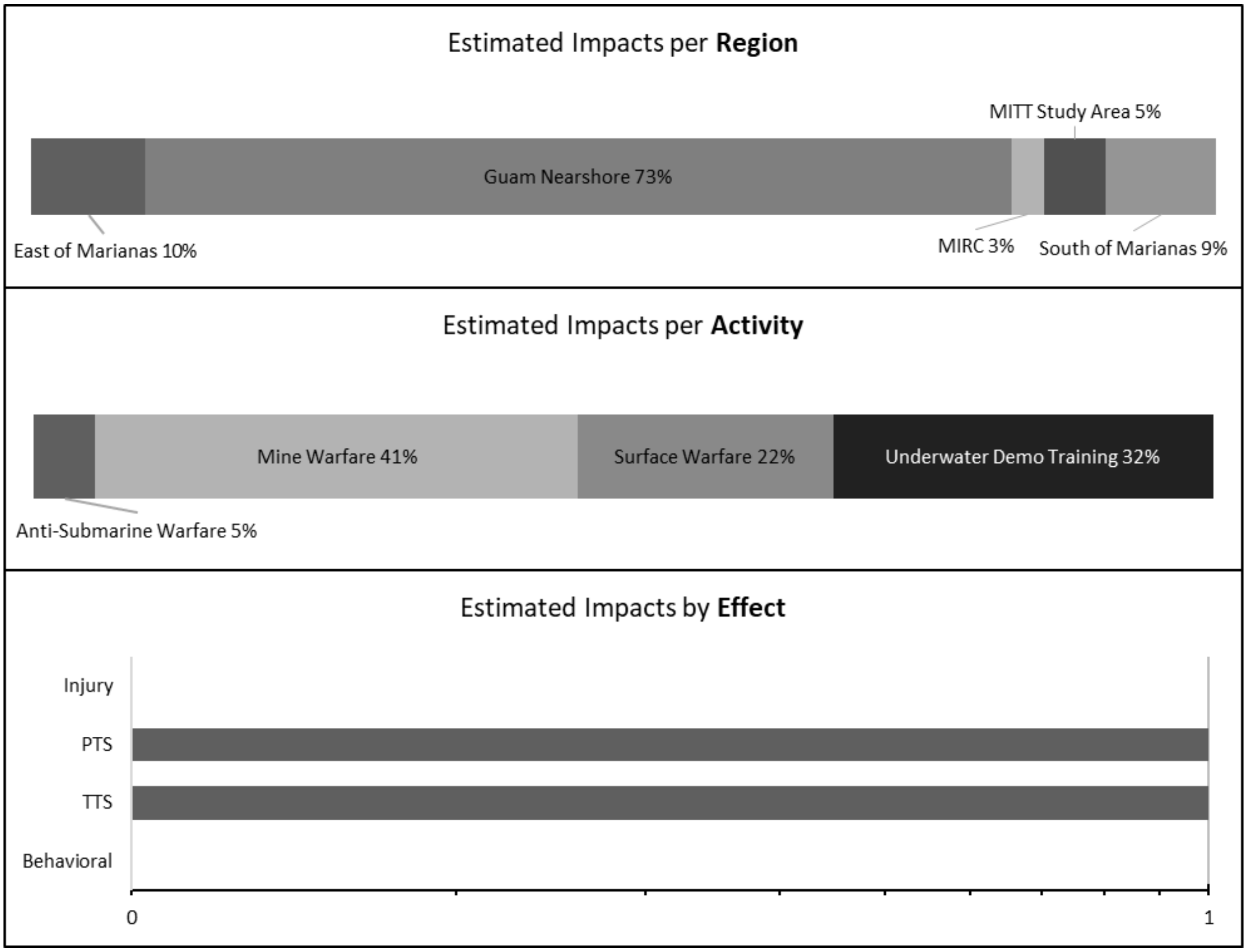
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No behavioral responses, PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-91: Spinner Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Spinner dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 2, estimates TTS and PTS (see Figure 3.4-92 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. As described for odontocetes above, even a few minor to moderate TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS could reduce an animal’s ability to detect biologically important sounds; however, as discussed above, a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that spinner dolphins rely upon. Nevertheless, PTS could have minor long-term consequences for individuals. This minor consequence for an individual is unlikely to have any long-term consequences for the species. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of spinner dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No behavioral responses or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

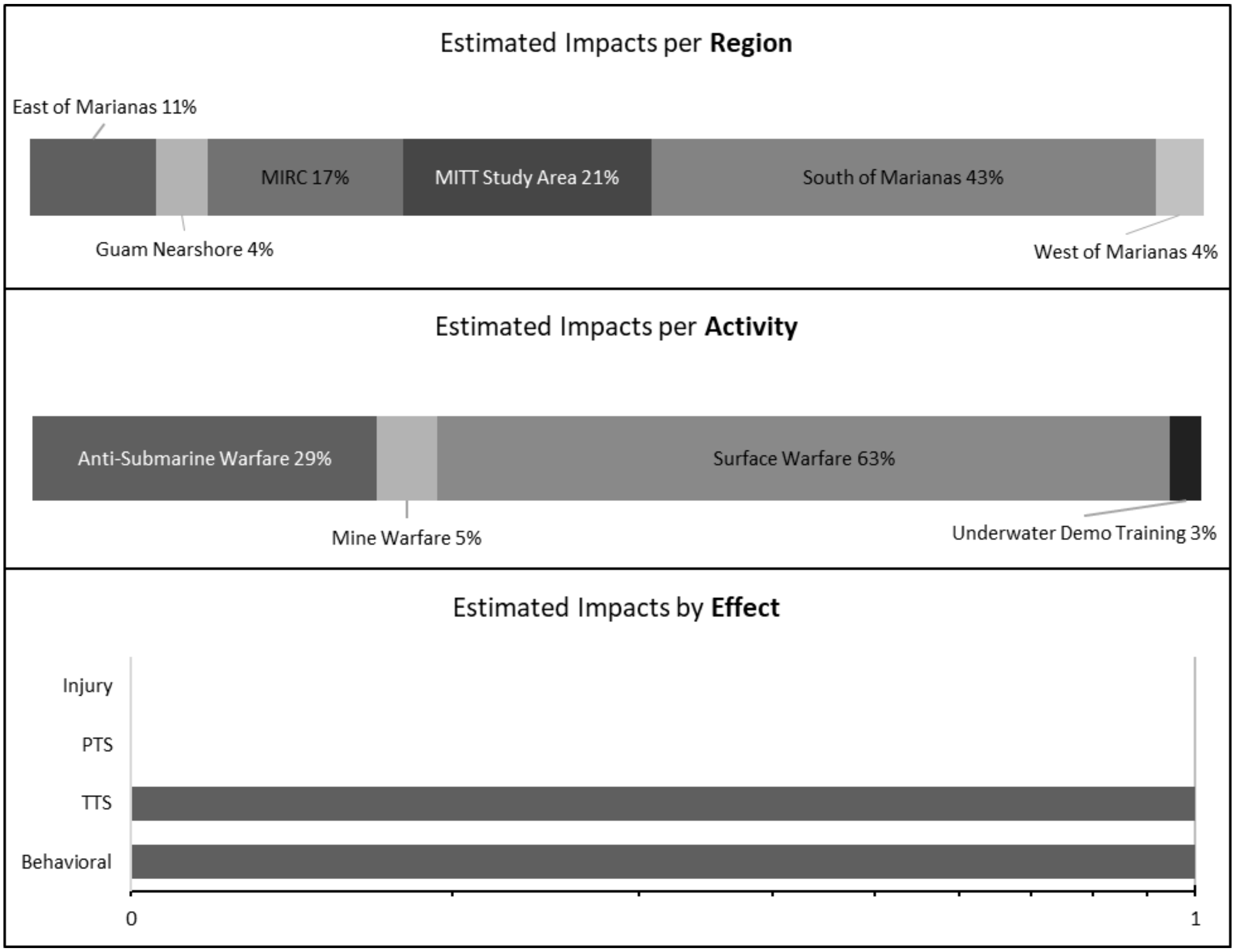
Figure 3.4-92: Spinner Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Striped Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Striped dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 1, estimates behavioral reaction and TTS (see Figure 3.4-93 and tabular results in Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS or behavioral reaction to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of striped dolphins incidental to those activities.



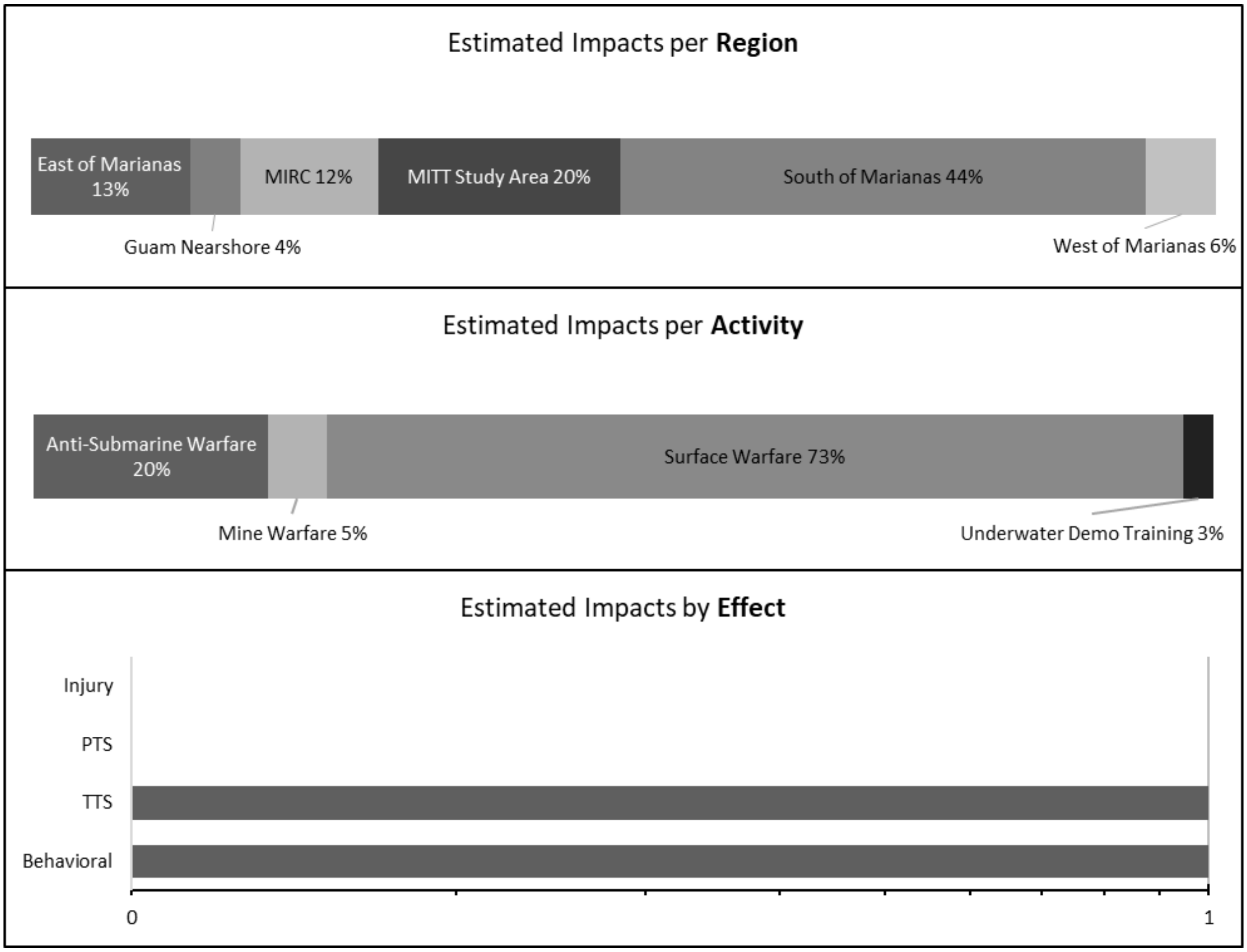
Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-93: Striped Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly (see Figure 3.4-94) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities; however, the total number of impacts would remain the same.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of striped dolphins incidental to those activities.



Notes: (1) Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. Estimated impacts most years would be less based on fewer explosions. No PTS or injuries (non-auditory) are estimated for this species. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-94: Striped Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

3.4.2.2.2.4 Impacts from Explosive Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Explosive stressors, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that use explosives within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from explosive stressors on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.3 Energy Stressors

Energy stressors are discussed in Section 3.0.4.3 (Energy Stressors) of this SEIS/OEIS. The energy stressors that may impact marine mammals include in-water electromagnetic devices and high-energy lasers. NMFS has previously determined in documents and analyses associated with two prior Navy training and testing EIS/OEISs within the MITT Study Area that in-water electromagnetic devices would not result in harassment or the incidental taking of marine mammals (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). These determinations for this stressor were recently reaffirmed for a third time by NMFS for the same actions elsewhere (83 FR 10954 & 83 FR 29872). Since the 2015 MITT Final EIS/OEIS and with the increased use of undersea power cables associated with offshore energy generation, there has been renewed scientific interest in electromagnetic fields possibly affecting migrating marine mammals (Gill et al., 2014; Kremers et al., 2014; Kremers et al., 2016; Zellar et al., 2017). Horton et al. (2017) have indicated that future experiments involving empirical observation of free-ranging animals are still required for there to be sufficient evidence demonstrating causal relations between marine mammal movement decisions and environmental cues such as the earth's magnetic field. These additional scientific findings do not change in any way the rationale for the dismissal of in-water electromagnetic devices as presented in the 2015 analyses given a negligible or discountable impact on marine mammal populations or species.

The 2015 MITT Final EIS/OEIS covered the use of low-energy lasers in Section 3.0.5.2.2.3 (Lasers), but high-energy laser weapons were not part of the Proposed Action in the 2015 MITT Final EIS/OEIS. The use of high-energy lasers represents a new sub-stressor as part of an existing activity in this SEIS/OEIS. As discussed in this SEIS/OEIS, Section 3.0.4.3.2.2 (High-Energy Lasers), high-energy lasers are designed to disable surface targets, rendering them immobile. The primary concern is the potential for a marine mammal to be struck with the laser beam at or near the water's surface, where extended exposure could result in injury or death.

As described in Section 3.0.4.3.2 (Lasers), high-energy laser weapons testing activities involve evaluating the effectiveness of a high-energy laser deployed from a surface ship to create small but critical failures in potential targets from short ranges. The concern with the proposed use of high-energy lasers is the potential for a marine mammal to be exposed to the laser beam if the laser beam missed the target, if the animal was above the ocean surface, and if the animal was in the direct path of the laser beam in front of or directly behind the target. The Navy conducted statistical modeling to estimate the probability of a marine mammal being struck by a high-energy laser during training and testing activities. The probability was estimated for a location off Southern California where the density of marine mammals is generally higher than in the Study Area and where more training and testing activities using high-energy lasers are conducted. The results of the analysis showed that there is a very low probability of a direct strike by a high-energy laser on a marine mammal, and that the likelihood of a strike occurring is therefore discountable (U.S. Department of the Navy, 2017b). Given that marine mammal densities are lower in the Study Area and fewer activities using high-energy lasers would be conducted in the Study Area, it is reasonable to conclude that the probability of a direct strike is even lower than predicted off Southern California. Therefore, it is reasonable to conclude that marine mammals in the Study Area are not likely to be struck by a high-energy laser. Training and testing activities have the potential to expose marine mammals that occur within the Study Area to this energy stressor. However, given the short ranges involved in the activities involving high-energy lasers, the aim point being a surface target, the inherent precision of the weapon and its targeting system, and the fact that marine mammals spend up to 90 percent of their time under the water (Costa, 1993; Costa & Block, 2009), indicates that impacts on marine mammals from high-energy lasers should not be expected to occur.

3.4.2.3.1 Impacts from Energy Stressors Under Alternative 1

Under Alternative 1, the number of proposed training and testing activities involving the use of in-water electromagnetic devices would decrease in comparison to the 2015 MITT Final EIS/OEIS (see Table 3.0-9). These activities would occur in the same locations and in a similar manner as previously analyzed. Therefore, as stated in the 2015 MITT Final EIS/OEIS and based on the new science summarized above, the impact of in-water electromagnetic devices on marine mammals are not expected.

Under Alternative 1, there would be up to 54 activities annually that include the use of high-energy lasers (Table 3.0-10). As discussed above, impacts on marine mammals from high-energy lasers are not expected because of the very low probability of a direct strike by a high-energy laser on a marine mammal.

Impacts on marine mammals from energy stressors, including in-water electromagnetic devices and high-energy lasers, are not expected to occur under Alternative 1.

The use of in-water electromagnetic devices and high-energy lasers as described under Alternative 1 would not result in the unintentional taking of marine mammals incidental to those activities as defined under the MMPA.

Pursuant to the ESA, the use of in-water electromagnetic devices and high-energy lasers as described under Alternative 1 may affect ESA-listed marine mammals.

3.4.2.3.2 Impacts from Energy Stressors Under Alternative 2

Under Alternative 2, the number of proposed training and testing activities involving energy stressors would be the same as Alternative 1 for in-water electromagnetic devices (Table 3.0-9). Under Alternative 2, the use of high-energy lasers would increase as compared to Alternative 1 (Table 3.0-10). There would be no change regarding the impact conclusions for energy stressors as summarized above under Alternative 1 and as presented in the 2015 MITT Final EIS/OEIS. Therefore, impacts on marine mammals under Alternative 2 from energy stressors, including high-energy lasers, are not expected to occur.

The use of in-water electromagnetic devices and high-energy lasers as described under Alternative 2 would not result in the unintentional taking of marine mammals incidental to those activities as defined under the MMPA.

Pursuant to the ESA, the use of in-water electromagnetic devices and high-energy lasers as described under Alternative 2 may affect ESA-listed marine mammals.

3.4.2.3.3 Impacts from Energy Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with the Proposed Action would continue to occur. Energy stressors from the use of in-water electromagnetic devices and high-energy lasers, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that produce energy stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from energy stressors on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.4 Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors are discussed in Section 3.0.4.4 (Physical Disturbance and Strike Stressors) of this SEIS/OEIS. The physical disturbance and strike stressors that may impact marine mammals include (1) vessels and in-water devices, (2) military expended materials, and (3) seafloor devices. The annual number of activities including vessels and in-water devices, the annual number of military expended materials, and the annual number of activities including seafloor devices are shown in Table 3.0-12 through Table 3.0-18.

Since 1995, the U.S. Navy has reported all known or suspected vessel collisions with whales to NMFS, and there have been no known collisions between Navy vessels and whales in the MITT Study Area associated with any of the proposed training or testing activities. The Navy has several standard operating procedures and mitigation measures for vessel safety that will benefit marine mammals through a reduction in the potential for vessel strike, as discussed in Section 2.3.3 (Standard Operating Procedures) and Chapter 5 (Mitigation). Based on the absence of any Navy vessel strikes associated with the Proposed Action in the Study Area, the general reduction in strike incidents Navy-wide since introduction of the Marine Species Awareness Training in 2006, and the future reduction in vessel and in-water device use in comparison to the ongoing actions (see Tables 3.0-12 and 3.0-13), the Navy does not anticipate the occurrence of future vessel strikes to marine mammals within the Study Area during training and testing activities. For these reasons, the Navy is not requesting authorization of a take by vessel strike during Navy training and testing activities in the MITT Study Area.

Most in-water devices, such as unmanned underwater vehicles and towed devices, will move slowly through the water and are highly unlikely to strike marine mammals because the mammal could easily avoid the device. In-water devices towed by manned platforms 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-water devices that could pose a higher risk to marine mammals are those operated at high speeds and unmanned, such as 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 tactical software that guides U.S. Navy torpedoes is sophisticated and should not identify a marine mammal as a target. All training and testing torpedoes are recovered after being fired at targets and are reconfigured for re-use. Review of the exercise torpedo records indicates there has never been an impact on a marine mammal. 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 mammal strike.

As part of military expended materials, small-caliber munitions are inert, are meant to be aimed at targets, and are not long-range weapons. As a result, marine mammals are extremely unlikely to be disturbed or struck by expended small-caliber munitions. There have been no known instances of a seafloor device (such as an anchor) striking a marine mammal as it was being deployed or recovered.

In short, there have been no known instances of physical disturbance or strike to any marine mammals as a result of training and testing activities prior to or since the 2015 MITT Final EIS/OEIS. As described in Section 5.3.4 (Physical Disturbance and Strike Stressors), the Navy will continue to implement mitigation measures for applicable vessel movements, towed in-water devices, and military expended materials during non-explosive activities. The mitigation measures will further avoid or reduce the already low potential for impacts on marine mammals during activities involving physical disturbance or strike stressors.

NMFS has previously determined in documents and analyses associated with two prior Navy training and testing EIS/OEISs within the MITT Study Area that physical disturbance and strike stressors would not result in harassment or the incidental taking of marine mammals (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). There has been no subsequent emergent science that would necessitate changes to these conclusions, reached in association with the 2015 MITT Final EIS/OEIS analyses, regarding physical disturbance and strike stressors being dismissed as having a negligible or discountable impact on marine mammal populations or species.

3.4.2.4.1 Impacts from Physical Disturbance and Strike Stressors Under Alternative 1

Under Alternative 1, analysis of the individual sub-stressors including the use of vessels and in-water devices, military expended materials, and seafloor devices presented in Section 3.0.4.4 (Physical Disturbance and Strike Stressors) indicates that those items having the most potential to affect marine mammals have decreased in comparison to the 2015 MITT Final EIS/OEIS (Tables 3.0-12 through 3.0-18). This assumes the dismissal of small-caliber munitions for the reasons noted above.

Given the reduction in physical disturbance and strike stressors for this SEIS/OEIS, the findings presented in the 2015 MITT Final EIS/OEIS, Section 3.4.4.4 (Physical Disturbance and Strike Stressors), the MMPA authorization (80 FR 46112), and the NMFS Biological Opinion, the findings associated with the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015b) remain valid.

The use of vessels and in-water devices, military expended materials, and seafloor devices under Alternative 1 would not result in the unintentional taking of marine mammals incidental to those activities as defined as defined under MMPA.

Pursuant to the ESA, the use of vessels and in-water devices, military expended materials, and seafloor devices as summarized above under Alternative 1 may affect ESA-listed marine mammals.

3.4.2.4.2 Impacts from Physical Disturbance and Strike Stressors Under Alternative 2

Under Alternative 2, physical disturbance and strike stressors during training and testing activities would decrease in comparison to the 2015 (Tables 3.0-12 through 3.0-18) assuming the dismissal of small-caliber munitions use for the reasons noted above. Under Alternative 2, there would be additional physical disturbance and strike stressors in comparison to Alternative 1, but the conclusions remain the same. Therefore, impacts on marine mammals from physical disturbance and strike stressors are not expected to occur.

The use of vessels and in-water devices, military expended materials, and seafloor devices under Alternative 2 would not result in the unintentional taking of marine mammals incidental to those activities as defined under MMPA.

Pursuant to the ESA, the use of vessels and in-water devices, military expended materials, and seafloor devices may affect ESA-listed marine mammals.

3.4.2.4.3 Impacts from Physical Disturbance and Strike Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with the Proposed Action would continue to occur. Physical disturbance and strike stressors from the use of vessels and in-water devices, military expended materials, and seafloor devices, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing training and testing activities would result in fewer activities that produce physical disturbance and strike stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from physical disturbance and strike stressors on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.5 Entanglement Stressors

Entanglement stressors are discussed in Section 3.0.4.5 (Entanglement Stressors) of this SEIS/OEIS. Entanglement stressors considered for marine mammals include (1) wires and cables, and (2) decelerators/parachutes. The annual numbers of wires and cables and decelerators/parachutes proposed under the alternatives and in comparison to current ongoing activities are presented in Tables 3.0-20 through 3.0-22. There have been no known instances of any marine mammals being entangled in wires and cables, or decelerators/parachutes associated with Navy training and testing activities prior to or since the 2015 MITT Final EIS/OEIS.

NMFS has previously determined in documents and analyses associated with two prior Navy training and testing EIS/OEISs within the MITT Study Area that entanglement stressors would not result in harassment or the incidental taking of marine mammals (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). There has been no subsequent emergent science that would necessitate changes to these conclusions, reached in association with the 2015 MITT Final EIS/OEIS analyses, regarding this stressor being dismissed as having a negligible or discountable impact on marine mammal populations or species. These determinations for this stressor were recently reaffirmed for a third time by NMFS for the same actions elsewhere (83 FR 10954 & 83 FR 29872).

3.4.2.5.1 Impacts from Entanglement Stressors Under Alternative 1

Under Alternative 1, the annual number of entanglement stressors would decrease in comparison to the current ongoing activities (Tables 3.0-20 through 3.0-22). Therefore, the analysis from the 2015 MITT Final EIS/OEIS remains valid. The analysis presented in the 2015 MITT Final EIS/OEIS (Section 3.4.4.5, Entanglement Stressors), the MMPA authorization (80 FR 46112), and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015b) determined that entanglement stressors associated with the Navy's Proposed Action can be dismissed as having a negligible or discountable impact on marine mammal populations or species.

The use of wires and cables and decelerators/parachutes as described under Alternative 1 would not result in the unintentional taking of marine mammals incidental to those activities as defined under the MMPA.

Pursuant to the ESA, the use of wires and cables and parachutes/decelerators as described under Alternative 1 may affect ESA-listed marine mammals.

3.4.2.5.2 Impacts from Entanglement Stressors Under Alternative 2

Under Alternative 2, the number of entanglement stressors would decrease in comparison to current ongoing activities (Tables 3.0-20 through 3.0-22). In comparison to Alternative 1, there would be a slight increase under Alternative 2 for entanglement stressors; however, the combined number of annual entanglement stressors (fiber optic cable, guidance wire, and decelerators/parachutes) decreases when compared to the 2015 MITT Final EIS/OEIS. Therefore, the analysis and conclusions presented in the 2015 MITT Final EIS/OEIS (Section 3.4.4.5, Entanglement Stressors), the MMPA authorization (80 FR 46112), and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015b) remain valid. Impacts on marine mammals from the use of entanglement stressors are not anticipated.

The use of wires and cables and decelerators/parachutes as described under Alternative 2 would not result in the unintentional taking of marine mammals incidental to those activities as defined under the MMPA.

Pursuant to the ESA, the use of wires and cables and parachutes/decelerators as described under Alternative 2 may affect ESA-listed marine mammals.

3.4.2.5.2.1 Impacts from Entanglement Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with the Proposed Action would continue to occur. Entanglement stressors from the use of wires and cables and decelerators/parachutes, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that use entanglement stressors within the marine environment where Navy training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from entanglement stressors on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.6 Ingestion Stressors

Ingestion stressors are discussed in Section 3.0.4.6 (Ingestion Stressors) of this SEIS/OEIS. Types of materials that could become ingestion stressors during training and testing in the Study Area include military expended materials – munitions and military expended materials – other than munitions. The annual number of activities including military expended materials are shown in Tables 3.0-14 through 3.0-17, 3.0-20 and 3.0-21, and Tables 3.0-23 through 3.0-25. As discussed in Section 3.4.4.6.3 (Impacts from Munitions) of the 2015 MITT Final EIS/OEIS, the number of munitions and explosive munitions fragments that an individual marine mammal could encounter would generally be low, based on the patchy distribution of both the munitions and the habitats where marine mammals forage. For the more numerous small-caliber munitions, these expended material type items are inert, small, do not resemble prey items, and end up as part of the seafloor, where they are unlikely to be encountered by most marine mammals. In addition, it is assumed for marine mammal species that may feed at the seafloor, that they would not ingest every munition or munition's fragment encountered; if a munition or munition's fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. There is evidence indicating that even ingestion of certain metal items (e.g., hooks) may not result in injury or mortality to the individual (Wells et al., 2008; West, 2016).

NMFS has previously determined in documents and analyses associated with two prior Navy training and testing EIS/OEISs within the MITT Study Area that ingestion stressors would not result in harassment or the incidental taking of marine mammals (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). There has been no subsequent emergent science that would necessitate changes to these conclusions reached in association with the 2015 MITT Final EIS/OEIS analyses regarding this stressor being dismissed as having a negligible or discountable impact on marine mammal populations or species. These determinations for this stressor were recently reaffirmed for a third time by NMFS for the same actions elsewhere (83 FR 10954 & 83 FR 29872).

3.4.2.6.1 Impacts from Ingestion Stressors Under Alternative 1

Under Alternative 1, analysis of the individual sub-stressors presented in Section 3.0.4.6 (Ingestion Stressors) indicates that those items considered ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) having the most potential to affect marine mammals have decreased (Tables 3.0-14 through 3.0.17, Table 3.0-20 and 3.0-21, and Tables 3.0-23 through 3.0-25). For the reasons noted above, the Navy has determined that potential impacts from ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) would not be substantially different from the 2015 MITT Final EIS/OEIS. In the 2015 analysis of training and testing activities within the Study Area, NMFS determined that ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) would not result in harassment or the incidental taking of marine mammals activities (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). The activities expending munitions and other military expended materials analyzed in this SEIS/OEIS under Alternative 1 are not a significant change over what was analyzed in the 2015 MITT Final EIS/OEIS, and there has been no new science necessitating a revision of the 2015 conclusions in that regard. Impacts on marine mammals from ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) associated with Navy activities in the Study Area are not anticipated.

The use of military expended materials as described under Alternative 1 would not result in the unintentional taking of marine mammals incidental to those activities as defined under the MMPA.

Pursuant to the ESA, the use of military expended materials as described under Alternative 1 may affect ESA-listed marine mammals.

3.4.2.6.2 Impacts from Ingestion Stressors Under Alternative 2

Under Alternative 2, the use of military expended materials would decrease under this SEIS/OEIS in comparison to the ongoing activities, with the exception of increased small-caliber munitions use (Tables 3.0-14 through 3-17 and Tables 3.0-22 through 3.0-24). Under Alternative 2, increases as compared to Alternative 1 do not change the impact conclusions for ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) as summarized above under Alternative 1 and as presented in the 2015 MITT Final EIS/OEIS. Therefore, impacts on marine mammals from ingestion of military expended materials under Alternative 2 are not expected.

The use of military expended materials as described under Alternative 2 would not result in the unintentional taking of marine mammals incidental to those activities as defined under the MMPA.

Pursuant to the ESA, the use of military expended materials as described under Alternative 2 may affect ESA-listed marine mammals.

3.4.2.6.3 Impacts from Ingestion Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with the Proposed Action would continue to occur. Ingestion stressors from the use of military expended materials – munitions and military expended materials – other than munitions, as described above, would not be introduced into the marine environment under the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of on-going training and testing activities. Discontinuing the training and testing activities would result in fewer activities that produce ingestion stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from ingestion stressors on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.7 Secondary Stressors

As discussed in Section 3.4.4.7 (Secondary Stressors) of the 2015 MITT Final EIS/OEIS, secondary stressors from training and testing activities were analyzed for potential indirect impacts on marine mammals via habitat degradation or an effect on prey availability. These stressors included (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 on sediments and water quality are discussed in detail in Section 3.1 (Sediments and Water Quality) of the 2015 MITT Final EIS/OEIS and in Section 3.1 (Sediments and Water Quality) of this SEIS/OEIS. NMFS has previously determined in documents and analyses associated with two prior Navy training and testing EIS/OEISs within the MITT Study Area that secondary stressors would not result in harassment or the incidental taking of marine mammals (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). There has been no subsequent emergent science since 2015 that would necessitate changes to the analysis of secondary stressors being dismissed as having a negligible or discountable impact on marine mammal populations or species. These determinations for secondary stressors were recently reaffirmed for a third time by NMFS for the same actions elsewhere (83 FR 10954 and 83 FR 29872).

The current analysis has concluded that the relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment, from either high-order or low-order detonations, are relatively low and readily diluted. For example, degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Rosen & Lotufo, 2010). Any remnant undetonated components from explosives such as TNT, royal demolition explosive, and high melting explosive experience rapid biological and photochemical degradation in marine systems (Cruz-Uribe et al., 2007; Juhasz & Naidu, 2007; Pavlostathis & Jackson, 2002; Singh et al., 2009; Walker et al., 2006).

For undetonated munitions, the concentration of unexploded ordnance, explosion byproducts, metals, and other chemicals would never exceed that of a World War II dump site, where studies found minimal concentrations were detected only within a few feet of the ordnance (Briggs et al., 2016; Edwards & Bełdowski, 2016; Edwards et al., 2016a; Edwards et al., 2016b; Kelley et al., 2016; Koide et al., 2015; University of Hawaii, 2010). Annual surveys conducted in the waters off Farallon de Medinilla from 1999 through 2012 found no evidence that the habitat had changed or been adversely impacted to a significant degree by the training activities that have been conducted there (Smith & Marx, 2016). Therefore, long-term secondary effects on marine mammal habitat or prey would be negligible.

The potential transmission of diseases or parasites from Navy marine mammals to indigenous marine mammals is highly unlikely for the following reasons: the Navy marine mammals spend a very small amount of time in the open ocean; the Navy trainers have excellent control over the animals; the Navy follows procedures for the collection and proper disposal of marine mammal waste; the Navy's marine mammals are screened and receive exceptional veterinarian care; the Navy conducts visual monitoring for indigenous marine mammals to avoid any interactions with Navy marine mammals; and the Navy has a track record of over 40 years, with zero known incidents. As described in detail in Section 3.4.4.7.5 (Transmission of Marine Mammal Diseases and Parasites) in the 2015 MITT Final EIS/OEIS, there is no scientific basis to conclude that the use of Navy marine mammals during training and testing activities would have an indirect impact on wild marine mammals.

Secondary stressors from training and testing activities as described under Alternative 1, Alternative 2, and the No Action Alternative, would not result in the unintentional taking of marine mammals incidental to those stressors as defined under the MMPA.

Pursuant to the ESA, secondary stressors from training and testing activities, as described under Alternative 1, Alternative 2, and the No Action Alternative, may affect ESA-listed marine mammals.

3.4.3 Summary of Potential Impacts on Marine Mammals

As described in Section 3.0.5.4 (Resource-Specific Impacts Analysis for Multiple Stressors) in the 2015 MITT Final EIS/OEIS, 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 Section 3.4.2.1 (Acoustic Stressors) through Section 3.4.2.6 (Ingestion Stressors) and, for ESA-listed species, summarized in Section 3.4.5 (Endangered Species Act Determinations).

Understanding the combined effects of stressors on marine organisms in general and marine mammal populations in particular is extremely difficult to predict (National Academies of Sciences Engineering and Medicine, 2017). Recognizing the difficulties with measuring trends in marine mammal populations, the focus has been on indicators for adverse impacts, including health and other population metrics (National Academies of Sciences Engineering and Medicine, 2017). This recommended use of population indicators is the approach Navy presented in the 2015 MITT Final EIS/OEIS (Section 3.4.5, Summary of Impacts on Marine Mammals) and formed part of the 2015 analyses by NMFS in their MMPA authorization (80 FR 46112), and the Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015b).

Stressors associated with training and testing activities do not typically occur in isolation but rather occur in some combination. For example, mine neutralization activities include elements of acoustic, physical disturbance and strike, entanglement, ingestion, and secondary stressors that are all coincident in space and time. An analysis of the combined impacts of all stressors considers the potential consequences of additive stressors and synergistic stressors, as described below. This analysis makes the reasonable assumption, which is supported by the acoustic effects modeling, that the majority of exposures to stressors are non-lethal, and instead focuses on consequences potentially impacting marine mammal fitness (e.g., physiology, behavior, reproductive potential).

There are generally two ways that a marine mammal could be exposed to multiple additive stressors. The first would be if a marine mammal were exposed to multiple sources of stress from a single event or activity within a single event (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 proposed under Alternative 1 generally involve the use of moving platforms (e.g., ships, torpedoes, aircraft) that may produce one or more stressors; therefore, it is likely that if a marine mammal were within the potential impact range of those activities, it may be impacted by multiple stressors simultaneously. Individual stressors that would otherwise have minimal to no impact may combine to have a measurable response. However, due to the wide dispersion of stressors, speed of the platforms, general dynamic movement of many training and testing activities, and behavioral avoidance exhibited by many marine mammal species, it is very unlikely that a marine mammal would remain in the potential impact range of multiple sources or sequential events. Exposure to multiple stressors is more likely to occur at an instrumented range where training and testing activities using multiple platforms may be concentrated during a particular event. In such cases involving a relatively small area on an instrumented range, a behavioral reaction resulting in avoidance of the immediate vicinity of the activity would reduce the likelihood of exposure to additional stressors. Nevertheless, the majority of the proposed activities are unit-level training and testing activities, which are conducted in the open ocean. 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).

Secondly, a marine mammal could be exposed to multiple training and testing activities over the course of its life; however, training and testing activities are generally separated in space and time in such a way that it would be unlikely that any individual marine mammal would be exposed to stressors from multiple activities within a short timeframe. 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.

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. Research and monitoring efforts have included before, during, and after-event observations and surveys, 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. To date, the findings from the research and monitoring and the regulatory conclusions from previous analyses by NMFS in the MMPA authorization (80 FR 46112) and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS

(National Oceanic and Atmospheric Administration, 2015b) have been that the majority of impacts from training and testing activities are not expected to have deleterious impacts on the fitness of any individuals or long-term consequences to populations of marine mammals.

3.4.3.1 Combined Impacts of All Stressors Under Alternative 1

Although potential impacts on certain marine mammal species from training and testing activities under Alternative 1 may include injury to individuals, those injuries are not expected to lead to long-term consequences for populations. The potential impacts anticipated from Alternative 1 are summarized in Section 3.4.4 (Marine Mammal Protection Act Determinations) and Section 3.4.5 (Endangered Species Act Determinations) for each regulation applicable to marine mammals. For a discussion of cumulative impacts, see Chapter 4 (Cumulative Impacts). For a discussion of mitigation, see Chapter 5 (Mitigation) and Appendix I (Geographic Mitigation Assessment).

3.4.3.2 Combined Impacts of All Stressors Under Alternative 2

As detailed previously in this section, some training and testing activities proposed under Alternative 2 would be an increase over what is proposed for Alternative 1. However, this increase is not expected to significantly increase the potential for impacts over what is analyzed for Alternative 1. The analysis presented in Section 3.4.3.1 (Combined Impacts of All Stressors Under Alternative 1) would similarly apply to Alternative 2. The combined impacts of all stressors for training and testing activities under Alternative 2 are not expected to have deleterious impacts or long-term consequences to populations of marine mammals.

3.4.3.3 Combined Impacts of All Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with the Proposed Action would continue to occur. All stressors associated with training and testing activities would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.4.3.4 Summary of Monitoring and Observations During Navy Activities Since 2015

As provided in detail in the 2015 MITT Final EIS/OEIS, Section 3.4.5.2 (Summary of Observations During Previous Navy Activities), the results of previous monitoring and research since 2006 taking place in and around Navy ranges and occurring before, during, and after Navy training and testing events, have been included as part of the Navy analyses as well as the analyses by NMFS in their MMPA authorization (National Oceanic and Atmospheric Administration, 2015b), and the Biological Opinion for the 2015 MITT Final EIS/OEIS (National Marine Fisheries Service, 2015b).

Since 2006, the Navy, non-Navy marine mammal scientists, and research groups and 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. The analysis provided in this SEIS/OEIS will be the third time Navy training and testing activities at sea have been comprehensively analyzed in the Study Area. Data collected from Navy monitoring, scientific research findings, and annual reports have been provided to NMFS; this public record is informative as part of the analysis of impacts on marine mammals in general for a variety of reasons, including species distribution, habitat use, and evaluation of potential responses to Navy activities.

Monitoring across Navy training and testing ranges is performed using a variety of methods, including visual surveys from surface vessels and aircraft; in addition, passive acoustics before, during, and after

Navy activities have been conducted. The Navy also has continued to contribute to funding of basic research, including behavioral response studies specifically designed to determine the effects to marine mammals from the Navy's use of mid-frequency sonar and other transducers.

The majority of the training and testing activities Navy is proposing in the Study Area are similar if not nearly identical to activities that have been occurring in the same locations for decades. For example, the mid-frequency sonar system on the Navy's cruisers and destroyers training in the Study Area have the same sonar system components in the water as those first deployed in the 1970s. While the signal analysis and computing processes onboard these ships have been upgraded with modern technology, the sonar transducers, which put signals into the water, have not changed. For this reason, the history of past marine mammal observations, research, and monitoring remain applicable to the analysis of effects from the proposed future training and testing activities in the Study Area.

It is still the case that in the Pacific, the vast majority of scientific field work, research, and monitoring efforts have been expended in Southern California and Hawaii where Navy training and testing activities have been most concentrated. Since 2006, the Navy has been submitting exercise reports and monitoring reports to NMFS for the Navy's range complexes, including monitoring conducted before, during, and after training and testing activities. These publically available exercise reports, monitoring reports, and the associated scientific research findings have been integrated into decisions regarding the focus for subsequent research and monitoring as determined in collaborations between Navy, NMFS, Marine Mammal Commission, and other marine resource subject matter experts using an adaptive management approach.

In the Study Area, because training and testing events are less frequent and general small in scope by comparison to other Navy areas, the majority of Navy's research effort has been focused elsewhere. Despite this, funding by the Navy has provided nearly the entirety of marine mammal science collected in the Mariana Islands. In fact, prior to Navy funding of marine mammal science, there had not been any dedicated marine mammal surveys performed in the Mariana Islands. The bulk of these Navy-funded research efforts span two primary methodologies: small-vessel surveys and bottom-moored acoustic deployments. These primary data collection methods have been supplemented by additional results from autonomous gliders acoustic survey, acoustic towed-arrays, visual survey from shore-stations, marine mammal observers on large-vessel surveys, and further analysis and collection of incidental and stranding data. Since the 2015 MITT Final EIS/OEIS, new research has continued to be funded by Navy in the Mariana Islands and has included, but is not limited to the following findings:

- The continuation of annual small vessel nearshore surveys, sightings, satellite tagging, biopsy and genetic analysis, photo-identification, and opportunistic acoustic recording off Guam, Saipan, Tinian, Rota, and Aguigan in partnership with NMFS (Hill et al., 2015b; Hill et al., 2016b; Hill et al., 2017a). The satellite tagging and genetic analyses have resulted in the first information discovered on the movement patterns, habitat preference, and population structure of multiple odontocete species in the Study Area.
- Since 2015, the addition of a series of small vessel surveys in the winter season dedicated to humpback whales has provided new information relating to the occurrence, calving behavior, and population identity of this species (Hill et al., 2016a; Hill et al., 2017b), which has not previously been sighted during the previous small vessel surveys in the summer or winter. This work has included sighting data, photo ID matches of individuals to other areas demonstrating migration as well as re-sights within the Mariana Islands across different years, and the collection of biopsy samples for genetic analyses of populations.

- The continued deployment of passive acoustic monitoring devices and analysis of acoustic data obtained using bottom-moored acoustic recording devices deployed by NMFS has provided information on the presence and seasonal occurrence of mysticetes, as well as the occurrence of cryptic odontocetes typically found offshore, including beaked whales and Kogia whales (Hill et al., 2015b; Hill et al., 2016a; Hill et al., 2016b; Hill et al., 2017a; Munger et al., 2015; Norris et al., 2017; Oleson et al., 2015; Yack et al., 2016).
- Acoustic surveys using autonomous gliders were used to characterize the occurrence of odontocetes and mysticetes in abyssal offshore waters near Guam and Commonwealth of the Northern Mariana Islands (CNMI), including species not seen in the small vessel visual survey series such as killer whales and Risso's dolphins. Analysis of collected data also provided new information on the seasonality of baleen whales, patterns of beaked whale occurrence and potential call variability, and identification of new unknown marine mammal calls (Klinck et al., 2016b; Nieukirk et al., 2016).
- Visual surveys were conducted from a shore-station at high elevation on the north shore of Guam to document the nearshore occurrence of marine mammals in waters where small vessel visual surveys are challenging due to regularly high sea states (Deakos & Richlen, 2015; Deakos et al., 2016).
- Analysis of archive data, including marine mammal sightings during Guam Department of Agriculture Division of Aquatic and Wildlife Resources aerial surveys undertaken between 1963 and 2012 (Martin et al., 2016).
- Analysis of archived acoustic towed-array data for an assessment of the abundance and density of minke whales (Norris et al., 2017), abundance and density of sperm whales (Yack et al., 2016), and the characterization of sei and humpback whale vocalizations (Norris et al., 2014).

As detailed in the 2015 MITT Final EIS/OEIS, these reporting, monitoring, and research efforts by the Navy have added to the baseline data for marine mammal species inhabiting the Study Area. In addition, subsequent research and monitoring across the Navy has continued to broaden the sample of observations regarding the general health of marine mammal populations in locations where Navy has been conducting training and testing activities for decades, which has been considered in the analysis of marine mammal impacts presented in this SEIS/OEIS in the same manner that the previous findings were used in the 2015 MITT Final EIS/OEIS, the NMFS authorization of takes under MMPA (National Oceanic and Atmospheric Administration, 2015b), and the NMFS Biological Opinion pursuant to the ESA (National Marine Fisheries Service, 2015b).

This public record of training and testing activities, monitoring, and research from across the Navy range complexes in the Pacific and Atlantic now spans more than 13 years. Given that this record involves many of the same Navy training and testing activities being considered for the Study Area, and includes all the marine mammal taxonomic families present in the Study Area, many of the same species, and perhaps some of the same populations as they seasonally migrate from other range complexes, this compendium of Navy reporting is directly applicable to the Study Area. It was the Navy's assessment in the 2015 MITT Final EIS/OEIS and that of NMFS, as reflected in their analysis of previous Navy training and testing in the Study Area (National Marine Fisheries Service, 2015b; National Oceanic and Atmospheric Administration, 2015b), that it was unlikely there would be impacts on populations of marine mammals (such as whales, dolphins, and pinnipeds) having any long-term consequences as a result of the proposed continuation of training and testing in the Study Area. This assessment of likelihood is based on four indicators from areas in the eastern 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) 13 years of comprehensive monitoring data indicating a lack of obvious observable effects such as direct mortalities or strandings occurring in marine mammal populations as a result of Navy training and testing activities. Consistent with the presentation in the 2015 MITT Final EIS/OEIS, the evidence to date and since 2015 continues to suggest the viability of marine mammal populations where the Navy trains and tests and does not show any direct evidence suggesting Navy training and testing has had or may have any long-term consequences to marine mammal populations. Barring any evidence to the contrary, therefore, what limited evidence there is from monitoring reports and additional other focused scientific investigations should be considered in the analysis of impacts on marine mammals. For the Study Area in particular and since the analysis in 2015, examples include

- the most current information suggesting that the ESA-listed blue whale population in the Pacific, which includes the Study Area as part of their habitat, may have recovered and been at a stable level based on recent surveys and scientific findings (Barlow, 2016; Campbell et al., 2015; Carretta et al., 2017d; Monnahan et al., 2015; Rockwood et al., 2017; Širović et al., 2015); and
- humpback whales continue to use Northern Mariana Islands as a winter calving area (Fulling et al., 2011; Hill et al., 2016a; Hill et al., 2017b; Hill et al., 2018a).

To summarize and bring up to date the findings from the 2015 MITT Final EIS/OEIS, the evidence from reporting, monitoring, and research across the Pacific over more than a decade indicates that while the Proposed Action would result in harassment of marine mammals and may include injury to some individuals, these impacts are expected to be inconsequential at the level of their marine mammal populations. Monitoring of Navy training and testing will continue to confirm this expectation, as it has in the past in locations where Navy training and testing occurs. Across this past monitoring as well as the broader scientific literature, no direct evidence exists that routine Navy training and testing spanning decades has negatively impacted marine mammal populations at any Navy Range Complex or the Study Area. In particular, there is no evidence that would directly contradict the analysis in the 2015 MITT Final EIS/OEIS or this SEIS/OEIS, such as the regular observation of strandings, injuries, or mortalities associated temporarily and spatially with Navy training and testing events.

For some of the most intensively used Navy training and testing areas, evidence such as the continued multi-year presence of long-term resident individual animals and small populations (Baird et al., 2015; Baird et al., 2016; Baird et al., 2017; Schorr et al., 2014; Schorr et al., 2018; U.S. Department of the Navy, 2017b), resident females documented with and without calves from year to year, and high abundances on the Navy ranges for some species in comparison to other off-range locations (Moore & Barlow, 2017; Schorr et al., 2018; U.S. Department of the Navy, 2017b), indicates generally healthy marine mammal populations. Therefore, based on the best available science, including data developed in exercise and monitoring reports submitted to NMFS for over a decade, long-term consequences for marine mammal populations are unlikely to result from Navy training and testing activities in the Study Area.

3.4.4 Marine Mammal Protection Act Determinations

As required by Section 101(a)(5)(A) of the MMPA, the Navy is seeking a Letter of Authorization from NMFS for the use of sonar and other transducers and explosives during Navy activities under Alternative 1 or Alternative 2 of the Proposed Action. The use of sonar and other transducers may result in Level A and Level B harassment of certain marine mammals. The use of explosives may result in Level A harassment, Level B harassment. Refer to Section 3.4.2.1.2 (Impacts from Sonar and Other Transducer Stressors) for details on the estimated impacts from sonar and other transducers and Section 3.4.2.2.2 (Impacts from Explosive Stressors) for impacts from explosives. Based on best available science, the Navy concludes that impacts from sonar and other transducers and from explosives to marine mammal species and stocks would result in only short-term effects on most individuals exposed and would not affect annual rates of recruitment or survival for the following reasons:

- Most acoustic exposures are within the non-injurious temporary threshold shift or behavioral effects zones (Level B harassment).
- Although the numbers presented in Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) represent estimated harassment under the MMPA and they are conservative estimates (i.e., overpredictions) of harassment, primarily by behavioral disturbance.
- The Navy Acoustic Effects Model calculates harassment without taking into consideration mitigation measures, and is not indicative of a likelihood of either injury or harm. Additionally, the mitigation measures described in Chapter 5 (Mitigation) are designed to avoid or reduce sound exposure and explosive effects on marine mammals to levels below those that may cause injury and to achieve the least practicable adverse effect on marine mammal species or stocks.

Weapons noise, vessel noise, aircraft noise, the use of in-water electromagnetic devices, in-air electromagnetic devices, high-energy lasers, vessels, in-water devices, seafloor devices, wires and cables, decelerators/parachutes, and military expended materials are not expected to result in Level A or Level B harassment of any marine mammals.

3.4.5 Endangered Species Act Determinations

Pursuant to the ESA, Navy training and testing activities presented in this SEIS/OEIS may affect ESA-listed marine mammals. There is no designated critical habitat for any marine mammal species in the MITT Study Area. The Navy will consult with NMFS as required by section 7(a)(2) of the ESA. The outcome of those consultations pursuant to ESA will be described in the MITT Final SEIS/OEIS.

3.4.6 Public Scoping Comments

The public raised a number of issues during the scoping period for this supplement in regard to marine mammals. The issues are summarized in the list below.

- Concern that there be analysis of impacts on marine mammals from various stressors associated with the Proposed Action (e.g., sonar, explosives, “chemical pollution,” destruction of habitat) – Section 3.4.2 (Environmental Consequences) analyzed potential impacts from sonar and other active acoustic stressors, explosives, electromagnetic energy, physical disturbances and strikes, entanglement, ingestion, and secondary stressors. Impacts from sonar and explosives were reanalyzed for several reasons described in Section 3.4.2.1 (Acoustic Stressors) and Section 3.4.2.2 (Explosive Stressors). The analysis of other stressors is summarized in the Section 3.4.2.3 (Energy Stressors) through Section 3.4.2.7 (Secondary Stressors) and described in detail in the 2015 MITT Final EIS/OEIS.
- **Concerns over the amount of take of marine mammals authorized** – The number and species of marine mammals exposed to sonar and explosives (the only stressors predicted to result in a “take” of a marine mammal) are presented in Section 3.4.2.1.2 (Impacts from Sonar and Other

Transducer Stressors) and Section 3.4.2.2.2 (Impacts from Explosive Stressors). The vast majority of predicted impacts are behavioral reactions to sonar or explosives.

- **The analysis must address direct and cumulative impacts on marine mammals** – Direct impacts on marine mammals are addressed in the stressor sections above. A detailed analysis of impacts from acoustic and explosive stressors is provided in Section 3.4.2.1 (Acoustic Stressors) and Section 3.4.2.2 (Explosive Stressors). Impacts from other stressors are summarized in Section 3.4.2.3 (Energy Stressors) through Section 3.4.2.7 (Secondary Stressors) and described in detail in the 2015 MITT Final EIS/OEIS. Chapter 4 (Cumulative Impacts) addresses potential impacts from the Proposed Action in combination with other past, present, and future activities occurring in the Study Area. Cumulative impacts on marine mammals are likely when considering the variety of stressors (e.g., bycatch) that pose a threat to marine mammal populations. Refer to Section 3.4.1.7 (General Threats).
- **Recommendation that this SEIS/OEIS must evaluate alternatives that include temporal and habitat avoidance or time/area closures including restrictions on activities in areas biologically sensitive or important areas** – Regarding the development of alternatives considered, see Section 2.4 (Action Alternatives Development). With regard to the topic specifically, see Section 2.4.1.3 (Alternatives Including Geographic Mitigation Measures within the Study Area) for a discussion on why alternatives including these types of mitigation measures are not generally feasible. A new Appendix I (Geographic Mitigation Assessment) has been included in this SEIS/OEIS to further evaluate areas specifically identified in public scoping comments as areas to consider for geographic/temporal mitigation. Based on the analysis in Appendix I (Geographic Mitigation Assessment), in Chapter 5 (Mitigation), in association with the MMPA and the ESA permitting processes, and other required regulatory consultations, consideration of geographic mitigation has been considered for implementation under both action alternatives.
- **The supplement must include analysis and description of mitigation measures implemented to reduce impacts on marine mammals** – Chapter 5 (Mitigation) provides a detailed description of mitigation measures associated with training and testing activities that would avoid or reduce potential impacts on marine mammals.
- **In-water surveys within the 3 miles around FDM should be conducted for marine mammals** – In-water surveys of marine resources within the 3 NM danger zone surrounding FDM have been conducted for more than a decade by Navy divers (see Smith and Marx (2009); Smith et al. (2013b); Smith and Marx (2016)). Research funding is allocated via the Integrated Comprehensive Monitoring Program (U.S. Department of the Navy, 2010, 2013a), which provides the overarching framework for coordination of the Navy’s marine species research and monitoring efforts and serves as a planning tool to focus Navy monitoring priorities pursuant to ESA and MMPA requirements. The purpose of the Integrated Comprehensive Monitoring Program is to coordinate monitoring efforts across all regions and to allocate the most appropriate level and type of monitoring effort for each range complex based on a set of standardized objectives, regional expertise, and resource availability. Although the Integrated Comprehensive Monitoring Program does not identify specific field work or individual projects, it is designed to provide a flexible, scalable, and adaptable framework using adaptive management and strategic planning processes that periodically assess progress and reevaluate objectives. The adaptive management review process is anticipated to continue between the Navy, NMFS, and the Marine Mammal Commission through technical review meetings and ongoing discussions.

- **The supplement must include the most recently published science cetacean reports for the Mariana Archipelago** – Relevant literature published since the 2015 MITT Final EIS/OEIS has been used throughout Section 3.4 (Marine Mammals) of this SEIS/OEIS. This includes approximately 160 new references cited in the section, which were published between January 2016 and June 2018 in addition to additional emergent works of science that considered in the analysis although not necessarily cited in this section.
- **The EIS must analyze humpback whale calving areas discussed by Hill et al. (2017b)** – Section 3.4.1.11 (Humpback Whale (*Megaptera novaeangliae*)) presents the current information and references with regard to the presence of humpback whales in the Mariana Islands. Note that Hill et al. (2017b) did not identify the location specific calving areas in the Mariana Islands, but indicated, "that the Marianas are a wintering area." Subsequent to Hill et al. (2017b) and recently, scientists have confirmed the Mariana Islands as a new breeding location for humpback whales in the western North Pacific (National Oceanic and Atmospheric Administration, 2018c). Chapter 5 (Mitigation) and Appendix I (Geographic Mitigation Assessment) contain detailed discussions of potential mitigation measures that were evaluated, including temporal and geographic mitigation for areas where humpback whales have been routinely sighted as detailed in various reports (Fulling et al., 2011; Hill et al., 2015a; Hill et al., 2015b; Hill et al., 2016a; Hill et al., 2016b; Hill et al., 2017a; Hill et al., 2017b; Hill et al., 2018a; National Oceanic and Atmospheric Administration, 2018c; Uyeyama, 2014). Based on the analysis in Chapter 5 (Mitigation) and Appendix I (Geographic Mitigation Assessment), the MMPA and the ESA permitting processes, and other required regulatory consultations, practical science-based mitigation measures, including temporal or geographic constraints within the Study Area, may be implemented under Alternative 1 or Alternative 2.

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