3.5 Sea Turtles

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3.5.1 Affected Environment

The purpose of this section is to supplement the analysis of impacts on sea turtles 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. Information presented in the 2015 MITT Final EIS/OEIS that remains valid is noted as such and referenced to the appropriate sections. Any new or updated information describing the affected environment and analysis of impacts on sea turtles associated with the Proposed Action is provided in this section. Comments received from the public during scoping related to sea turtles are addressed in Section 3.5.5 (Public Comments). Comments received from the public during the Draft Supplemental EIS (SEIS)/OEIS commenting period related to sea turtles are addressed in Appendix K (Public Comment Responses).

Only at-sea and Farallon de Medinilla (FDM) training and testing activities are subject to this SEIS/OEIS. Therefore, only effects within the nearshore and pelagic habitats for sea turtles are analyzed. The analysis of sea turtle presence and nesting on land presented in the 2015 MITT Final EIS/OEIS remains valid and continues to support these activities conducted within the Marianas.

The five sea turtle species potentially found in the Study Area are the same as those presented in the 2015 MITT Final EIS/OEIS and all are listed under the Endangered Species Act (ESA) as endangered or threatened (green sea turtle [*Chelonia mydas*], hawksbill sea turtle [*Eretmochelys imbricata*], loggerhead sea turtle [*Caretta caretta*], olive ridley sea turtle [*Lepidochelys olivacea*], and leatherback sea turtle [*Dermochelys coriacea*]). There is no critical habitat designated for sea turtle species within the Study Area. Similar to the 2015 MITT Final EIS/OEIS, this section provides an overview of the species, distribution, and occurrence of sea turtles, as well as new information released since the publication of the 2015 document. The status, presence, and nesting occurrence of sea turtles in the Study Area are listed by region in Table 3.5-1. Since the publication of the 2015 MITT Final EIS/OEIS, the National Marine Fisheries Service (NMFS) classified the global distribution of green sea turtles into distinct population segments (DPS). Within the area analyzed in this SEIS/OEIS, the endangered green sea turtle in the Mariana Islands has been determined to be part of the Central West Pacific DPS.

The Navy also reviewed the status and distribution of other pelagic reptile species, such as sea snakes, to evaluate if these species should be included in this SEIS/OEIS. There are no verified records of sea snakes in nearshore waters of the Mariana Islands. Eldredge (2003) notes that the few anecdotal reports of sea snakes are probably the result of confusion between the sea krate *Laticauda colubrina* commonly found on Palau and the snake eel *Myrichthys colubrinus*, indigenous to Guam. In the early 1970s there was a newspaper report of a yellow-bellied sea snake (*Pelamis platurus*) found on a Saipan beach (Eldredge, 2003). Sea snake occurrence in both pelagic and nearshore waters of the Study Area is extremely rare; therefore, sea snakes are not included in this SEIS/OEIS.

The 2015 MITT Final EIS/OEIS provided a general overview of sea turtle dive behavior, group size, and general threats. New information since the publication of the 2015 MITT Final EIS/OEIS is included below to better understand potential stressors and impacts on sea turtles resulting from training and testing activities.

Table 3.5-1: Endangered Species Act Status and Presence of Endangered Species Act Listed Sea Turtles in the Mariana Islands Training and Testing Study Area

Species Name and Regulatory Status				Presence in Study Area[1]	
Common Name		Scientific Name	Endangered Species Act Status	Open Ocean/Transit Corridor	Coastal/Ocean
Family Cheloniidae (hard-shelled sea turtles)					
Green sea turtle[2]	Central West Pacific DPS	*Chelonia mydas*	Endangered	Yes	Yes[3]
	East Indian-West Pacific DPS		Threatened		No
	Central North Pacific DPS		Threatened		No
Hawksbill sea turtle (throughout range)		*Eretmochelys imbricata*	Endangered	Yes	Yes[3,4]
Loggerhead sea turtle North Pacific DPS		*Caretta caretta*	Endangered[4]	Yes[5]	Yes[5]
Olive ridley sea turtle (Breeding populations on the Pacific coast of Mexico)		*Lepidochelys olivacea*	Endangered[6]	Yes[5]	Yes[5]
Family Dermochelyidae (leatherback sea turtle)					
Leatherback sea turtle (throughout range)		*Dermochelys coriacea*	Endangered	Yes[5]	Yes[5]

[1] MITT Study Area = Mariana Islands Training and Testing Study Area

[2] In 2015, NMFS published a final rule that classifies green sea turtles within the Study Area as part of the Western Pacific Distinct Population Segment. Green sea turtles within other DPS may occur within the Study Area—the East Indian-West Pacific DPS and the Central North Pacific DPS. These three DPS are analyzed individually in the section 7(a)(2) consultation between the Navy and NMFS.

[3] Indicates nesting activity within the Study Area. Only green sea turtles and hawksbill sea turtles are known to nest in the Study Area.

[4] The Northeast Atlantic Ocean, Mediterranean Sea, North Indian Ocean, North Pacific Ocean, and South Pacific Ocean Distinct Population Segments are listed as Endangered; the Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean, and Southwest Indian Ocean Distinct Population Segments are listed as threatened. Only loggerheads within the North Pacific Ocean DPS are within the Study Area.

[5] Species occurrence is only expected during migratory movements through the Study Area and therefore may be present, albeit at extremely low densities.

[6] Breeding populations of olive ridley sea turtles on the Pacific coast of Mexico are listed as endangered, and all other populations are listed as threatened. Both threatened and endangered populations could occur in the Study Area.

3.5.1.1 Group Size

Sea turtles are generally solitary animals, but they tend to group during migrations and mating. Because they do not show territoriality, foraging areas often overlap. New hatchlings, which often emerge from nesting beaches in groups, are solitary until they reach sexual maturity (Bolten, 2003; Bowen et al., 2004; James et al., 2005; Schroeder et al., 2003).

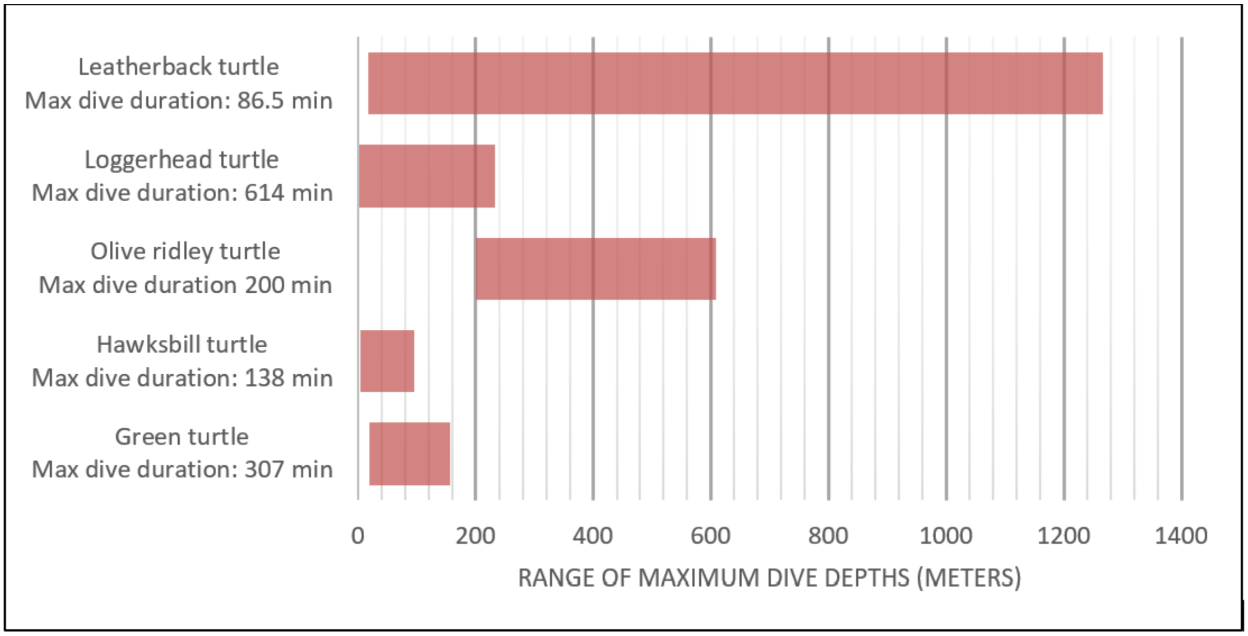
3.5.1.2 Habitat Use

Sea turtles are dependent on beaches for nesting habitat, in locations that have sand deposits that are not inundated with tides or storm events prior to hatching. In the water, sea turtle habitat use is dependent on species and corresponds to dive behavior because of foraging and migration strategies, as well as behavior state (e.g., diving deep at night for resting purposes) (Rieth et al., 2011).

3.5.1.3 Dive Behavior

Sea turtle dive depth and duration varies by species, the age of the animal, the location of the animal, and the activity (foraging, resting, and migrating). In addition, their relative distribution through the water column is an important consideration when conducting acoustic exposure analyses. The following text briefly describes the dive behavior of each species. Dive durations are often a function of turtle size, with larger turtles being capable of diving to greater depths and for longer periods. Methods of collecting dive behavior data over the years have varied in study design, configuration of electronic tags, parameters collected in the field, and data analyses.

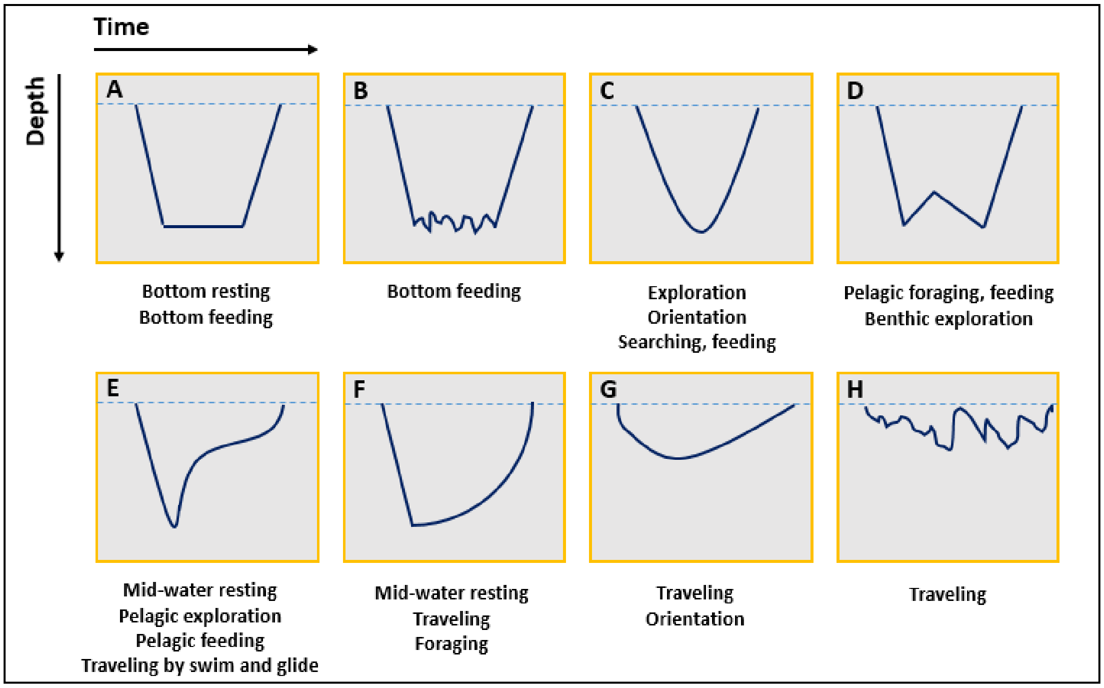
New information is available that improves the analysis for sea turtle dive behavior. Hochscheid (2014) has completed a species-specific summary for sea turtles within the Study Area that was not included in the 2015 MITT Final EIS/OEIS. Hochscheid (2014) collected data from 57 studies published between 1986 and 2013, which summarized depths and durations of dives of datasets including an overall total of 538 sea turtles. Figure 3.5-1 presents the ranges of maximum dive depths for each sea turtle species found in the Study Area. This summary is used to improve exposure analysis for stressors analyzed in Section 3.5.2 (Environmental Consequences).



Sources: Hochscheid (2014), Sakamoto et al. (1993), Rice and Balazs (2008), Gitschlag (1996), Salmon et al. (2004)

Figure 3.5-1: Dive Depth and Duration Summaries for Sea Turtle Species

Hochscheid (2014) also collected information on generalized dive profiles, with correlations to specific activities. Generalized dive profiles compiled from 11 different studies show 8 distinct profiles tied to specific activities. These profiles and activities are shown in Figure 3.5-2.



Sources: Hochscheid (2014); Rice and Balazs (2008), Sakamoto et al. (1993), Houghton et al. (2003), Fossette et al. (2007), Salmon et al. (2004), Hays et al. (2004); Southwood et al. (1999).

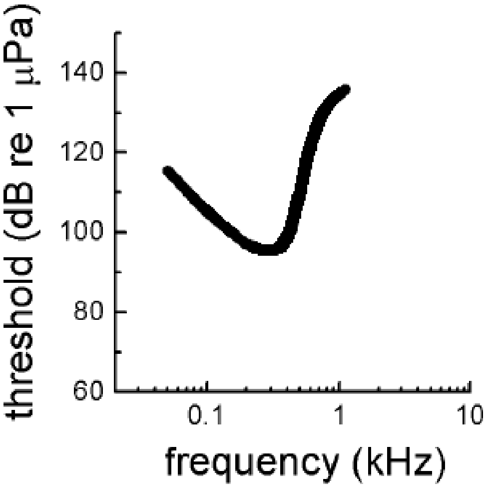
Notes: Profiles A-H, as reported in the literature and compiled by Hochscheid (2014). The depth and time arrows indicate the axis variables, but the figure does not represent true proportions of depths and durations for the various profiles. In other words, the depths can vary greatly, but behavioral activity seems to dictate the shape of the profile. Profiles G and H have only been described for shallow dives (less than 5 meters).

Figure 3.5-2: Generalized Dive Profiles and Activities Described for Sea Turtles

3.5.1.4 Hearing and Vocalization

Sea turtle ears are adapted for hearing underwater and in air, with auditory structures that may receive sound via bone conduction (Lenhardt et al., 1985), via resonance of the middle ear cavity (Willis et al., 2013), or via standard tympanic middle ear path (Hetherington, 2008). Studies of hearing ability show that sea turtles' ranges of in-water hearing detection generally lie between 50 and 1,600 hertz (Hz), with maximum sensitivity between 100 and 400 Hz, and that hearing sensitivity drops off rapidly at higher frequencies. Sea turtles are also limited to low frequency hearing in air, with hearing detection in juveniles possible between 50 to 800 Hz, with a maximum hearing sensitivity around 300–400 Hz (Bartol & Ketten, 2006; Piniak et al., 2016). Hearing abilities have primarily been studied with sub-adult, juvenile, and hatchling subjects in four sea turtle species, including green (Bartol & Ketten, 2006; Ketten & Moein-Bartol, 2006; Piniak et al., 2016; Ridgway et al., 1969; Yudhana et al., 2010), olive ridley (Bartol & Ketten, 2006), loggerhead (Bartol et al., 1999; Lavender et al., 2014; Martin et al., 2012), and leatherback (Dow Piniak et al., 2012). Only one study examined the auditory capabilities of an adult sea turtle (Martin et al., 2012); the hearing range of the adult loggerhead sea turtle was similar to other measurements of juvenile and hatchling sea turtle hearing ranges.

Using existing data on sea turtle hearing sensitivity, the U.S. Department of the Navy (Navy) developed a composite sea turtle audiogram for underwater hearing (Figure 3.5-3), as described 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).



Source: U.S. Department of the Navy (2017a)
Notes: dB re 1 µPa = decibels referenced to 1 micropascal, kHz = kilohertz

Figure 3.5-3: Composite Underwater Audiogram for Sea Turtles

The role of underwater hearing in sea turtles is unclear. Sea turtles may use acoustic signals from their environment as guideposts during migration and as cues to identify their natal beaches (Lenhardt et al., 1983). However, they may rely more on other senses, such as vision and magnetic orientation, to interact with their environment (Avens, 2003; Narazaki et al., 2013).

Sea turtles are not known to vocalize underwater. Some sounds have been recorded during nesting activities ashore, including belch-like sounds and sighs (Mrosovsky, 1972), exhale/inhales, gular pumps, and grunts (Cook & Forrest, 2005) by nesting female leatherback sea turtles and low-frequency pulsed and harmonic sounds by leatherback embryos in eggs and hatchlings (Ferrara et al., 2014).

3.5.1.5 General Threats

The general threats to sea turtles are described in the 2015 MITT Final EIS/OEIS. New information is available that provides a more refined understanding of how marine debris, potential invasive species introductions, and climate change can potentially threaten sea turtle species within the Study Area. Since the publication of the 2015 MITT Final EIS/OEIS, NMFS has classified green sea turtles occurring within the Mariana Islands as the Central West Pacific DPS. By doing so, the NMFS further defined threats to green sea turtles within this DPS; these threats are described below under species-specific threats for the green sea turtle. Although the information summarized below is from more recent literature since the publication of the 2015 MITT Final EIS/OEIS, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid, including the general threats to sea turtles.

3.5.1.5.1 Marine Debris

Ingestion of marine debris can cause injury or mortality to sea turtles if the debris does not pass through the digestive track. The United Nations Environment Program estimates that approximately 6.4 million tons of anthropogenic debris enters the marine environment every year (United Nations Environmental Program, 2005). This estimate, however, does not account for cataclysmic events, such as the 2011 Japanese tsunami estimated to have generated 1.5 million tons of floating debris (Murray et al., 2015). Plastic is the primary type of debris found in marine and coastal environments, and plastics are the most common type of marine debris ingested by sea turtles (Schuyler et al., 2014). Sea turtles can mistake debris for prey; one study found 37 percent of dead leatherback sea turtles ingested various types of plastic (Mrosovsky et al., 2009), and Narazaki et al. (2013) observed a loggerhead exhibiting hunting behavior on approach to a plastic bag, possibly mistaking the bag for a jelly fish. Ingesting even small amounts of plastic can cause an obstruction in a sea turtle's digestive track and mortality (Bjorndal et al., 1994; Bjorndal, 1997), and hatchlings are at risk for ingesting small plastic fragments. Plastics absorb toxins, such as bisphenol-A (commonly known as "BPA") and phthalates, as well as heavy metals from the ocean, and can be harmful to the tissues when ingested. (Fukuoka et al., 2016; Teuten et al., 2007). Life stage and feeding preference affects the likelihood of ingestion. Sea turtles living in oceanic or coastal environments and feeding in the open ocean or on the seafloor may encounter different types and densities of debris, and may therefore have different probabilities of ingesting debris. In 2014, Schuyler et al. (2014) reviewed 37 studies of debris ingestion by sea turtles, showing that young oceanic sea turtles are more likely to ingest debris (particularly plastic), and that green and loggerhead sea turtles were significantly more likely to ingest debris than other sea turtle species.

3.5.1.5.2 Invasive Species

Impacts on sea turtles associated with invasive species primarily concern nest predation and prey base. Some of the invasive species introduced to the larger, more populated islands in the Mariana archipelago are known nest predators (e.g., rats, feral dogs and cats, pigs, ants). Nests on populated islands are also at risk for illegal poaching (Kolinski et al., 2006). In foraging grounds, sea turtles have been shown to adapt their foraging preferences for invasive seagrass and algae. Becking et al. (2014) showed green sea turtle foraging behavior shift to consumption of *Halophila stipulacea*, a rapidly spreading seagrass in the Caribbean. In Hawaii, green sea turtles in Kaneohe Bay have modified their diets over several decades to include seven non-native species (*Acanthophora spicifera, Hypnea musciformis, Gracilaria salicornia, Eucheuma denticulatum, Gracilaria tikvahiae, Kappaphycus striatum,* and *Kappaphycus alvarezii*), with non-native algae accounting for over 60 percent of sea turtle diet (Russell & Balazs, 2015).

Since the publication of the 2015 MITT Final EIS/OEIS, the Navy has funded the *Regional Biosecurity Plan for Micronesia and Hawaii,* completed in 2015. Volume I, Appendix K of the biosecurity plan addresses general biosecurity recommendations for Guam and the Commonwealth of the Northern Mariana Islands, and Appendix M includes recommendations for U.S. Department of Defense activities (U.S. Department of the Navy, 2015d). Volume III includes a risk assessment for marine environments (U.S. Department of the Navy, 2015c), and Volume IV includes a risk assessment for potential introductions on land in terrestrial environments (U.S. Department of the Navy, 2015b). The 2015 biosecurity plan describes ongoing measures that reduce the potential for transport and introduction of invasive species resulting from military training and testing activities. Some of these species have the potential to degrade sea turtle habitats, reduce prey availability, or directly harm sea turtles. Because of the Navy's active biosecurity program, it is unlikely that training and testing activities would result in invasive species' introductions that would impact sea turtles. Therefore, invasive species are not analyzed as a new stressor in this SEIS/OEIS.

3.5.1.5.3 Climate Change

Since the publication of the MITT Final EIS/OEIS, the Navy has obtained and consolidated additional information to conceptualize the potential of climate change to threaten sea turtle species within the Study Area. Sea turtles are particularly susceptible to climate change effects because their life history, physiology, and behavior are extremely sensitive to environmental temperatures (Fuentes et al., 2013).

Climate change models predict sea level rise and increased intensity of storms and hurricanes in tropical sea turtle nesting areas (Patino-Martinez et al., 2008). These factors could significantly increase beach inundation and erosion, thus affecting water content of sea turtle nesting beaches and potentially inundating nests (Pike et al., 2015). Climate change may negatively impact turtles in multiple ways and at all life stages. These impacts may include the potential loss of nesting beaches due to sea level rise and increasingly intense storm surge (Patino-Martinez et al., 2008), feminization of turtle populations from elevated nest temperatures (and skewing populations from more males to females unless nesting shifts to northward cooler beaches) (Reneker & Kamel, 2016), decreased reproductive success (Clark & Gobler, 2016; Hawkes et al., 2006; Laloë et al., 2016; Pike, 2014), shifts in reproductive periodicity and latitudinal ranges (Birney et al., 2015; Pike, 2014), disruption of hatchling dispersal and migration, and indirect effects to food availability (Witt et al., 2010).

3.5.1.6 Green Sea Turtle (*Chelonia mydas*)

This section has been updated based on a change in the regulatory status of the green sea turtle and new information regarding trends and distributions of green sea turtles in nearshore waters of the Mariana Islands. As such, the life history and regulatory status descriptions for each sea turtle species differs in detail.

3.5.1.6.1 Status and Management

As presented in the 2015 MITT Final EIS/OEIS, green sea turtles are listed as threatened under the ESA throughout their Pacific range, except for the population that nests on the Pacific coast of Mexico (endangered). However, NMFS and United States Fish and Wildlife Service (USFWS) reclassified the species in 2016 into 11 DPSs, which maintains federal protections while providing a more tailored approach for managers to address specific threats facing different populations (see the NMFS and USFWS Final Rule published on April 6, 2016). Only the Central West Pacific DPS occurs within the Study Area. This DPS is listed as endangered under the ESA. Only this distinct population segment is discussed further in the document; however, it should be noted that minimal mixing (gene flow) may occur with other distinct population segments (Seminoff et al., 2015).

3.5.1.6.2 Habitat and Geographic Range

The habitat and geographic range of green sea turtles is described in the 2015 MITT Final EIS/OEIS. Following a review of recent literature, information on green sea turtles related to habitat and geographic range has not changed since the publication of the MITT Final EIS/OEIS. As such, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid. There is no critical habitat designated for this species in the Study Area. Seminoff et al. (2015), however, provides specific information for the Central West Pacific DPS and determined that this DPS is spatially bounded by the Asian continent to the west and north, the Solomon Islands to the south, the Marshall Islands in the east, and Palau in the west.

3.5.1.6.2.1 Population and Abundance

The population and abundance of green sea turtles is described in the 2015 MITT Final EIS/OEIS; however, new information is available for estimating abundance in waters within the Study Area. Martin et al. (2016) analyzed five decades of aerial surveys (from 1962 through 2012) to assess changes in marine megafauna on the insular coral reef ecosystem of Guam. Turtle observations (assumed to be primarily green sea turtles, but reported observations likely included some hawksbills) increased and varied spatially around Guam, with the highest densities occurring along the south, east, and north coasts, particularly in areas having low human density, reefs with coral cover, and either seagrass beds or a marine protected area. Observed individuals per survey ranged from 1.1 to 44.6 across all years. Based on this information, Martin et al. (2016) calculated a population growth rate of approximately 90 percent over the past five decades. Based on studies of in-water capture rates (where swimmers would capture and tag individual sea turtles), Martin et al. (2016) estimated that 85 percent of the sea turtles in waters off of Guam are green sea turtles, while 15 percent are hawksbill sea turtles. The Navy is currently funding in-water tagging of sea turtles in waters off of Guam, Tinian, and Saipan. Since November 2015 when tagging began, Falcone et al. (2017) report that the majority of sea turtles observed or captured (65 of 68 total sea turtles observed, or 96 percent) have been green sea turtles.

3.5.1.6.2.2 Predator-Prey Interactions

The predator-prey interactions relevant to green sea turtles are described in the 2015 MITT Final EIS/OEIS. Following a review of recent literature, information on green sea turtles related to predator-prey interactions has not changed since the publication of the 2015 MITT Final EIS/OEIS. As such, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid. When NMFS classified green sea turtles within the Central West Pacific DPS, no information on predator-prey interactions were used that were not included in the 2015 MITT Final EIS/OEIS.

3.5.1.6.2.3 Species-Specific Threats

Since the publication of the 2015 MITT Final EIS/OEIS, the NMFS has further defined threats to green sea turtles included in the Central West Pacific DPS. Damage to seagrass beds and declines in seagrass distribution can reduce foraging habitat for green sea turtles (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 1991; Seminoff et al., 2015; Williams, 1988). Green sea turtles are susceptible to the disease fibropapillomatosis, which causes tumor-like growths (fibropapillomas) resulting in reduced vision, disorientation, blindness, physical obstruction to swimming and feeding, increased susceptibility to parasites, and increased susceptibility to entanglement (Balazs, 1986; National Marine Fisheries Service & U.S. Fish and Wildlife Service, 1991; Patrício et al., 2016; Work & Balazs, 2013). The potential effects of disease and endoparasites also exist for green sea turtles found in the Central West Pacific Ocean. The loss of eggs to non-human predators is a severe problem in some areas. These predators include domestic animals, such as cats, dogs, and pigs, as well as wild species such as rats, mongoose, birds, monitor lizards, snakes, crabs, ants, and other invertebrates (Seminoff et al., 2015).

3.5.1.7 Hawksbill Sea Turtle (*Eretmochelys imbricata*)

The hawksbill sea turtle is listed as endangered under the ESA (35 Federal Register 8491). While the current listing as a single global population remains valid, data may support separating populations at least by ocean basin under the distinct population segment policy (National Marine Fisheries Service, 2013). The most recent status review was released in 2013 by the NMFS and USFWS (National Marine Fisheries Service, 2013). There is no critical habitat designated for this species in the Study Area. The regulatory status for the hawksbill sea turtle has remained unchanged since the publication of the 2015 MITT Final EIS/OEIS.

In addition, the life history information for hawksbill sea turtles occurring in nearshore and open ocean habitats within the Study Area has not changed since the publication of the 2015 MITT Final EIS/OEIS. New information is available for estimating hawksbill sea turtle population and abundance based off of five decades of aerial surveys in the nearshore waters of Guam. While Martin et al. (2016) estimated that approximately 15 percent of sea turtles observed in waters off of Guam are hawksbill sea turtles, tagging from November 2015 has revealed that only 4 percent of observed turtles are hawksbill sea turtles (Summers et al., 2017). Overall, the trend data over this time period suggests a dramatic increase in green and hawksbill sea turtle populations in waters around Guam. The Navy is currently funding in-water tagging of sea turtles in waters off of Guam, Tinian, and Saipan.

3.5.1.8 Loggerhead Sea Turtle (*Caretta caretta*)

In 2009, a status review was conducted for the loggerhead identified nine distinct population segments within the global population (Conant et al., 2009). In 2011, NMFS and USFWS listed five of these distinct population segments as endangered and kept four as threatened under the ESA. Only the North Pacific Ocean distinct population segment occurs within the Study Area; however, mixing is known to occur between other populations in the Pacific and Indian Oceans, enabling a limited amount of gene flow with other distinct population segments (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 2008). There is no critical habitat designated for this species in the Study Area. The regulatory status for the loggerhead sea turtle has remained unchanged since the publication of the 2015 MITT Final EIS/OEIS. In addition, the life history information for loggerhead sea turtles occurring in nearshore and open ocean habitats within the Study Area has not changed since the publication of the 2015 MITT Final EIS/OEIS. As such, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid.

3.5.1.9 Olive Ridley Sea Turtle (*Lepidochelys olivacea*)

Olive ridley sea turtles that nest along the Pacific coast of Mexico are listed as endangered under the ESA, while all other populations are listed under the ESA as threatened (43 Federal Register 32800). Based on genetic data, the worldwide olive ridley population is composed of four main lineages: east India, Indo-Western Pacific, Atlantic, and eastern Pacific Ocean (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 2014; Shankar et al., 2004). Most olive ridley sea turtles found within the Study Area are of the Indo-Western Pacific lineage (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 2014). There is no critical habitat designated for this species in the Study Area. The regulatory status for the olive ridley sea turtle has remained unchanged since the publication of the 2015 MITT Final EIS/OEIS.

In addition, the life history information for olive ridley sea turtles occurring in nearshore and open ocean habitats within the Study Area has not changed since the publication of the 2015 MITT Final EIS/OEIS. As such, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid.

3.5.1.10 Leatherback Sea Turtle (*Dermochelys coriacea*)

The leatherback sea turtle is listed as a single population and is classified as endangered under the ESA (35 Federal Register 8491). Recent information on population structure (through genetic studies) and distribution (through telemetry, tagging, and genetic studies) have led to an increased understanding and refinement of the global stock structure (Clark et al., 2010). There is no critical habitat designated for this species in the Study Area. The regulatory status for the leatherback sea turtle has remained unchanged since the publication of the 2015 MITT Final EIS/OEIS. In addition, the life history information for leatherback sea turtles occurring in nearshore and open ocean habitats within the Study Area has not changed since the publication of the 2015 MITT Final EIS/OEIS. As such, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid.

3.5.2 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, one new substressor (high-energy lasers) is being analyzed because of its potential to affect marine species, as detailed in Section 3.0.4.3.2.2 (High-Energy Lasers).

In general, there have been no substantial changes to the activities analyzed as the Proposed Action in the 2015 MITT Final EIS/OEIS which would change the conclusions reached regarding populations of sea turtles in the Study Area. Acoustic stressors (sonar and other transducers) and explosives have occurred since the 2015 completion of the MITT Record of Decision and ESA Biological Opinion. There have been no known impacts on sea turtles that were not otherwise previously analyzed or accounted for in the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015a), the NMFS Biological Opinion pursuant to ESA (National Marine Fisheries Service, 2015a), or the USFWS Biological Opinion.

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 completed a literature review for information on sea turtles within the Study Area, which included a search for the best available science since the publication of 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 previous 2015 MITT Final EIS/OEIS analysis. Where there has been substantive change in the action, science, or regulations, the information and analysis provided in in this SEIS/OEIS will supplement the 2015 MITT Final EIS/OEIS to support environmental compliance with applicable environmental statutes for sea turtles.

The stressors applicable to sea turtles in the Study Area for this SEIS/OEIS include the new stressor (high-energy lasers) and the same stressors considered in the 2015 MITT Final EIS/OEIS:

- **Acoustic** (sonar and other transducers, vessel noise, aircraft noise, and weapon noise)
- **Explosive** (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 and 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 sea turtles 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 sea turtles from acoustic, explosive, and physical disturbance and strike stressors. Mitigation for sea turtles has been coordinated with NMFS through the ESA consultation processes, and is detailed in Chapter 5 (Mitigation) and Appendix I (Geographic Mitigation Assessment) of this SEIS/OEIS.

In their biological opinion, NMFS determined that within the Study Area, only acoustic stressors and explosive stressors could potentially result in adverse effects on ESA-listed sea turtles from training and testing activities and that none of the other stressors would result in significant adverse impacts or jeopardize the continued existence of any ESA-listed sea turtle (National Oceanic and Atmospheric Administration, 2015).

The analysis presented in this section of this SEIS/OEIS also considers standard operating procedures that are described in Chapter 2 (Description of Proposed Action and Alternatives) and mitigation measures that are described in Chapter 5 (Mitigation). The Navy will implement these measures to avoid or reduce potential impacts on sea turtles from stressors associated with the proposed training and testing activities. Mitigation for sea turtles has been coordinated with NMFS through the ESA consultation process.

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 estimated impacts from sonar and other transduces 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 across multiple species, new information for sea turtles includes the integration of new sea turtle density data based on new survey data.

3.5.2.1 Acoustic Stressors

The analysis of effects to sea turtles follows the concepts outlined in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). This section begins with a summary of relevant data regarding acoustic impacts on sea turtles in Section 3.5.2.1.1 (Background). This is followed by an analysis of estimated impacts on sea turtles due to specific Navy acoustic stressors (sonar and other transducers, vessel noise, aircraft noise, and weapon noise). Additional explanations of the acoustic terms and sound energy concepts used in this section are found in Appendix H (Acoustic and Explosive Concepts). Studies of the effects of sound on sea turtles are limited; therefore, where necessary, knowledge of impacts on other species from acoustic stressors is used to assess impacts on sea turtles.

The Navy will rely on the previous 2015 MITT Final EIS/OEIS for the analysis of vessel noise, aircraft noise, and weapon noise, and new applicable and emergent science in regard to these substressors is presented in the sections that follow. Due to new acoustic impact criteria, sea turtle densities, and acoustic effects model, the analysis provided in Section 3.5.2.1.2 (Impacts from Sonar and Other Transducers) of this SEIS/OEIS will supplant the 2015 MITT Final EIS/OEIS for sea turtles, and may result in changes to estimated impacts for some species since the 2015 MITT Final EIS/OEIS.

3.5.2.1.1 Background

The sections below include a survey and synthesis of best-available-science published in peer-reviewed journals, technical reports, and other scientific sources pertinent to impacts on sea turtles potentially resulting from Navy training and testing activities. Sea turtles could be exposed to a range of impacts depending on the sound source and context of the exposure. Exposures to sound-producing activities may result in auditory or non-auditory trauma, hearing loss resulting in temporary or permanent hearing threshold shift, auditory masking, physiological stress, or changes in behavior.

3.5.2.1.1.1 Injury

The high peak pressures close to some non-explosive impulsive underwater sound sources may be injurious, although there are no reported instances of injury to sea turtles caused by these sources. A Working Group organized under the American National Standards Institute-Accredited Standards Committee S3, Subcommittee 1, Animal Bioacoustics, developed sound exposure guidelines for fish and sea turtles (Popper et al., 2014), hereafter referred to as the *ANSI Sound Exposure Guidelines*. Lacking any data on non-auditory sea turtle injuries due to sonars, the working group estimated the risk to sea turtles from low-frequency sonar to be low and mid-frequency sonar to be non-existent.

As discussed in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities, specifically Section 3.0.4.7.1, Injury), mechanisms for non-auditory injury due to acoustic exposure have been hypothesized for diving breath-hold animals. Acoustically induced bubble formation, rectified diffusion, and acoustic resonance of air cavities are considered for their similarity to pathologies observed in marine mammals stranded coincident with sonar exposures but were found to not be likely causal mechanisms (Section 3.5.2.1.1.1, Injury), and findings are applicable to sea turtles.

Nitrogen decompression due to modifications to dive behavior has never been observed in sea turtles. Sea turtles 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 (Lutcavage & Lutz, 1997). Although diving sea turtles experience gas supersaturation, gas embolism has only been observed in sea turtles bycaught in fisheries (Garcia-Parraga et al., 2014). Therefore, nitrogen decompression due to changes in diving behavior is not considered a potential consequence to diving sea turtles.

3.5.2.1.1.2 Hearing Loss

Exposure to intense sound may result in hearing loss, typically quantified as threshold shift, which persists after cessation of the noise exposure. Threshold shift is a loss of hearing sensitivity at an affected frequency of hearing. This noise-induced hearing loss may manifest as temporary threshold shift (TTS), if hearing thresholds recover over time, or permanent threshold shift (PTS), if hearing thresholds do not recover to pre-exposure thresholds. Because studies on inducing threshold shift in sea turtles are very limited (e.g., alligator lizards: Dew et al., 1993; Henry & Mulroy, 1995), are not sufficient to estimate TTS and PTS onset thresholds, and have not been conducted on any of the sea turtles present in the Study Area, auditory threshold shift in sea turtles is considered to be consistent with general knowledge about noise-induced hearing loss described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

Because there are no data on auditory effects on sea turtles, the *ANSI Sound Exposure Guidelines* (Popper et al., 2014) do not include numeric sound exposure thresholds for auditory effects on sea turtles. Rather, the guidelines qualitatively estimate that sea turtles are less likely to incur TTS or PTS with increasing distance from various sound sources. The guidelines also suggest that data from fishes may be more relevant than data from marine mammals when estimating impacts on sea turtles, because, in general, fish hearing range is more similar to the limited hearing range of sea turtles. As shown in Section 3.5.1.4 (Hearing and Vocalization), sea turtle hearing is most sensitive around 100–400 Hz in-water, is limited over 1 kilohertz (kHz), and is much less sensitive than that of any marine mammal. Therefore, sound exposures from most mid-frequency and all high-frequency sound sources are not anticipated to affect sea turtle hearing, and sea turtles are likely only susceptible to auditory impacts when exposed to very high levels of sound within their limited hearing range.

3.5.2.1.1.3 Physiological Stress

A stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. If the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the animal (e.g., decreased immune function, decreased reproduction). Physiological stress is typically analyzed by measuring stress hormones, other biochemical markers, or vital signs. Physiological stress has been measured for sea turtles during nesting (Flower et al., 2015; Valverde et al., 1999), capture and handling (Flower et al., 2015; Gregory & Schmid, 2001), and when caught in entanglement nets (Hoopes et al., 2000; Snoddy et al., 2009) and trawls (Stabenau et al., 1991). However, the stress caused by acoustic exposure has not been studied for sea turtles. Therefore, the stress response in sea turtles in the Study Area due to acoustic exposures is considered to be consistent with general knowledge about physiological stress responses described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

Marine animals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, nesting, and interactions with predators all contribute to stress. Anthropogenic sound-producing activities have the potential to provide additional stressors beyond those that naturally occur.

Due to the limited information about acoustically induced stress responses, the Navy conservatively 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.

3.5.2.1.1.4 Masking

As described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), auditory masking occurs when one sound, distinguished as the “noise,” interferes with the detection or recognition of another sound or limits the distance over which other biologically relevant sounds, including those produced by prey, predators, or conspecifics, can be detected. Masking only occurs when the sound source is operating; therefore, direct masking effects stop immediately upon cessation of the sound-producing activity. Any sound above ambient noise and within an animal’s hearing range may potentially cause masking.

Compared to other marine animals, such as marine mammals that are highly adapted to use sound in the marine environment, sea turtle hearing is limited to lower frequencies and is less sensitive. Because sea turtles likely use their hearing to detect broadband low-frequency sounds in their environment, the potential for masking would be limited to certain similar sound exposures. Only continuous human-generated sounds that have a significant low-frequency component, are not brief in duration, and are of sufficient received level, would create a meaningful masking situation (e.g., proximate vessel noise). Other intermittent, short-duration sound sources with low-frequency components (e.g., low-frequency sonars) would have more limited potential for masking depending on duty cycle.

There is evidence that sea turtles may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al., 2013) and magnetic orientation (Avens, 2003; Putman et al., 2015). Any effect of masking may be mediated by reliance on other environmental inputs.

3.5.2.1.1.5 Behavioral Reactions

Behavioral responses fall into two major categories: Alterations in natural behavior patterns and avoidance. These types of reactions are not mutually exclusive and reactions may be combinations of behaviors or a sequence of behaviors. As described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), the response of a sea turtle to an anthropogenic sound would likely depend on the frequency, duration, temporal pattern, and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). Distance from the sound source and whether it is perceived as approaching or moving away may also affect the way a sea turtle responds to a sound.

Sea turtles may detect sources below 2 kHz but have limited hearing ability above 1 kHz. They likely detect most broadband sources (including vessel noise) and low-frequency sonars, so they may respond to these sources. Because auditory abilities are poor above 1 kHz, detection and consequent reaction to any mid-frequency source is unlikely.

In the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), qualitative risk factors were developed to assess the potential for sea turtles to respond to various underwater sound sources. The guidelines state that there is a low likelihood that sea turtles would respond within tens of meters of low-frequency sonars, and that it is highly unlikely that sea turtles would respond to mid-frequency sources. The risk that sea turtles would respond to other broadband sources, such as shipping, is considered high within tens of meters of the sound source, but moderate to low at farther distances.

Behavioral Reactions to Impulsive Sound Sources

There are limited studies of sea turtle responses to sounds from impulsive sound sources, and all data come from sea turtles exposed to seismic air guns, although air guns are not used during MITT training or testing activities. These exposures consist of multiple air gun shots, either in close proximity or over long durations, so it is likely that observed responses may over-estimate responses to single or short-duration impulsive exposures. Studies of responses to air guns are used to inform sea turtle responses to other impulsive sounds (e.g., some weapon noise).

O'Hara and Wilcox (1990) attempted to create a sound barrier at the end of a canal using seismic air guns. They reported that loggerhead sea turtles kept in a 300-meter by 45-meter enclosure in a 10-meter deep canal maintained a minimum standoff range of 30 meters from air guns fired simultaneously at intervals of 15 seconds with strongest sound components within the 25–1,000 Hz frequency range. McCauley et al. (2000) estimated that the received sound pressure level (SPL) at which turtles avoided sound in the O'Hara and Wilcox (1990) experiment was 175–176 decibels referenced to 1 micropascal (dB re 1 µPa).

Moein Bartol et al. (1995) investigated the use of air guns to repel juvenile loggerhead sea turtles from hopper dredges. Sound frequencies of the air guns ranged from 100 to 1,000 Hz at three source SPLs: 175, 177, and 179 dB re 1 µPa at 1 m. The turtles avoided the air guns during the initial exposures (mean range of 24 meters), but additional exposures on the same day and several days afterward did not elicit statistically significant avoidance behavior. They concluded that this was likely due to habituation.

McCauley et al. (2000) exposed a caged green and a caged loggerhead sea turtle to an approaching-departing single air gun to gauge behavioral responses. The trials showed that above a received SPL of 166 dB re 1 µPa, the turtles noticeably increased their swimming activity compared to nonoperational periods, with swimming time increasing as air gun SPLs increased during approach. Above 175 dB re 1 µPa, behavior became more erratic, possibly indicating the turtles were in an agitated state. The authors noted that the point at which the turtles showed more erratic behavior and exhibited possible agitation would be expected to approximate the point at which active avoidance to air guns would occur for unrestrained turtles.

No obvious avoidance reactions by free-ranging sea turtles, such as swimming away, were observed during a multi-month seismic survey using air gun arrays, although fewer sea turtles were observed when the seismic air guns were active than when they were inactive (Weir, 2007). The author noted that sea state and the time of day affected both air gun operations and sea turtle surface basking behavior, making it difficult to draw conclusions from the data. However, DeRuiter and Doukara (2012) noted several possible startle or avoidance reactions to a seismic air gun array in the Mediterranean by loggerhead sea turtles that had been motionlessly basking at the water surface.

Based on the limited sea turtle behavioral response data discussed above, sea turtle behavioral responses to impulsive sounds could consist of temporary avoidance, increased swim speed, or changes in depth; or no response. Based on the behavioral response severity scale developed by Southall et al. (2007), the severity of these responses can be categorized as non-existent, low, and moderate.

Behavioral Reactions to Sonar and Other Transducers

Studies of sea turtle responses to non-impulsive sounds are very limited. Lenhardt (1994) used very low frequency vibrations (< 100 Hz) coupled to a shallow tank to elicit swimming behavior responses by two loggerhead sea turtles. Watwood et al. (2016) tagged green sea turtles with acoustic transponders and monitored them using acoustic telemetry arrays in Port Canaveral, FL. Sea turtles were monitored before, during, and after a routine pier-side submarine sonar test that utilized typical source levels, signals, and duty cycle. The sea turtles did not exhibit significant long-term displacement in this study. The authors note that Port Canaveral is an urban marine habitat and that resident sea turtles may be less likely to respond than naïve populations.

According to the qualitative risk factors developed in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), the likelihood of sea turtles responding to low- and mid-frequency sonar is low and highly unlikely, respectively. Based on the limited sea turtle behavioral response data discussed above, sea turtle behavioral responses to non-impulsive sounds could consist of temporary avoidance, increased swim speed, or no response. Using the behavioral response severity scale developed by Southall et al. (2007), the severity of these responses can be categorized as non-existent, low, and moderate.

3.5.2.1.1.6 Long-Term Consequences

For the sea turtles present in the Study Area, long-term consequences to individuals and populations due to acoustic exposures have not been studied. Therefore, long-term consequences to sea turtles due to acoustic exposures are considered following the framework presented in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

The long-term consequences due to individual behavioral reactions and short-term (seconds to minutes) instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies. 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 exposures to multiple stressors over significant periods of time. Conversely, some sea turtles may habituate to or become tolerant of repeated acoustic exposures over time, learning to ignore a stimulus that in the past did not accompany any overt threat. For example, loggerhead sea turtles exposed to air guns with a source SPL of 179 dB re 1 µPa initially exhibited avoidance reactions. However, they may have habituated to the sound source after multiple exposures, since a habituation behavior was retained when exposures were separated by several days (Moein Bartol et al., 1995). Intermittent exposures are assumed to be less likely to have lasting consequences.

3.5.2.1.2 Impacts from Sonar and Other Transducers

The overall use of sonar and other transducers for training and testing would be similar to what is currently conducted (see Table 2.5-1 and Table 3.0-2 for details). Although individual activities may vary somewhat from those previously analyzed, the overall determinations presented in the 2015 MITT Final EIS/OEIS remain valid. In addition, some new systems using new technologies would be tested under Alternatives 1 and 2. The quantitative analysis has been updated since the 2015 MITT Final EIS/OEIS; therefore, the new analysis is fully presented and described in further detail 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, 2017b).

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). Sonar and other transducers proposed for use are transient in most locations because activities that involve sonar and other transducers take place at different locations and many platforms are generally moving 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 activities that use sonar and other transducers are described in Appendix A (Training and Testing Activities Descriptions).

Sonar-induced acoustic resonance and bubble formation phenomena are very unlikely to occur under realistic conditions, as discussed in Section 3.5.2.1.1.1 (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.

Potential impacts considered from exposure to sonar and other transducers are hearing loss due to threshold shift (permanent or temporary), physiological stress, masking of other biologically relevant sounds, and changes in behaviors, as described in Sections 3.5.2.1.1.2 (Hearing Loss and Auditory Injury), Section 3.5.2.1.1.3 (Physiological Stress), Section 3.5.2.1.1.4 (Masking) and Section 3.5.2.1.1.5 (Behavioral Reactions).

3.5.2.1.2.1 Methods for Analyzing Impacts from Sonar and Other Transducers

The Navy performed a quantitative analysis to estimate the number of times that sea turtles could be affected by sonars and other transducers used during Navy training and testing activities. The Navy's quantitative analysis to determine impacts on sea turtles and marine mammals uses the Navy Acoustic Effects Model to produce initial estimates of the number of times these animals may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation. The steps of this quantitative analysis take into account

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

A further 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, 2018).

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

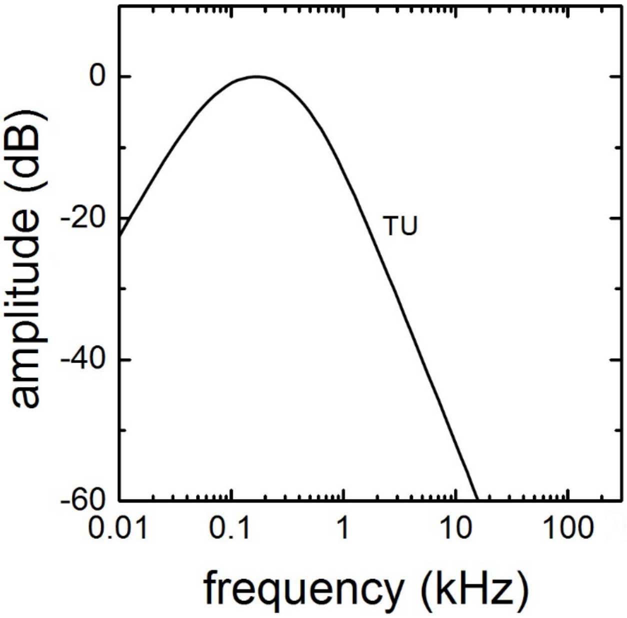
Auditory Weighting Functions

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. 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. The adjusted received sound level is referred to as a weighted received sound level.

The auditory weighting function for sea turtles is shown in Figure 3.5-4. The derivation of this weighting function is described 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). The frequencies around the top portion of the function, where the amplitude is closest to zero, are emphasized, while the frequencies below and above this range (where amplitude declines) are de-emphasized, when summing acoustic energy received by a sea turtle.

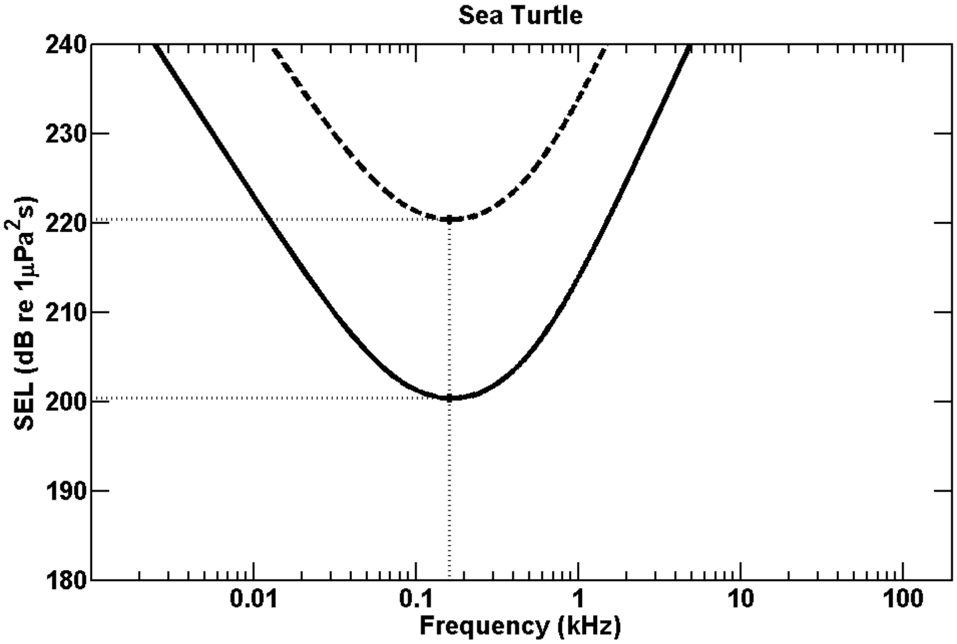
Hearing Loss from Sonar and Other Transducers

No studies of hearing loss have been conducted on sea turtles. Therefore, sea turtle susceptibility to hearing loss due to an acoustic exposure is evaluated using knowledge about sea turtle hearing abilities in combination with non-impulsive auditory effect data from other species (marine mammals and fish). This yields sea turtle exposure functions, shown in Figure 3.5-5, which are mathematical functions that relate the sound exposure levels (SELs) for onset of TTS or PTS to the frequency of the sonar sound exposure. The derivation of the sea turtle exposure functions 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).



Source: U.S. Department of the Navy (2017a)
Notes: dB = decibels, kHz = kilohertz, TU = sea turtle species group

Figure 3.5-4: Auditory Weighting Function for Sea Turtles



Source: U.S. Department of the Navy (2017a)
Notes: dB re 1 µPa2s: decibels referenced to 1 micropascal second squared, kHz = kilohertz. The solid black curve is the exposure function for TTS and the dashed black curve is the exposure function for PTS onset. Small dashed lines and asterisks indicate the SEL thresholds at the most sensitive frequency for TTS (200 dB) and PTS (220 dB).

Figure 3.5-5: TTS and PTS Exposure Functions for Sonar and Other Transducers

Accounting for Mitigation

The Navy will implement mitigation measures to avoid or reduce potential impacts from active sonar on sea turtles, 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 sea turtle is observed in a mitigation zone. The mitigation zones for active sonar activities were designed to avoid or reduce the potential for sea turtles 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 encompass the estimated ranges to injury (including PTS) for a given sonar exposure. Therefore, the impact analysis quantifies the potential for mitigation to reduce the risk of PTS. 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., 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, 2018).

In the quantitative analysis, consideration of mitigation measures means that, for activities where mitigation is feasible, 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 range to PTS was estimated for each training or testing event. The ability of Navy Lookouts to detect sea turtles in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as size or surface active behavior). The behaviors and characteristics of some species may make them easier to detect. Environmental conditions under which the training or testing activity could take place are also considered such as the 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, including the Marpi Reef Mitigation Area, Chalan Kanoa Reef Mitigation Area, and Agat Bay Nearshore Mitigation Area, as described in Appendix I (Geographic Mitigation Assessment). Mitigation areas are designed to help avoid or reduce impacts during biologically important life processes within particularly important habitat areas. The benefits of mitigation areas are discussed qualitatively in terms of the context of impact avoidance or reduction.

3.5.2.1.2.2 Impact Ranges for Sonar and Other Transducers

Because sea turtle hearing range is limited to a narrow range of frequencies and thresholds for auditory impacts are relatively high, there are few sonar sources that could result in exposures exceeding the sea turtle TTS and PTS thresholds. The representative bin of LF4 for PTS and TTS is zero meters. Ranges would be greater (i.e., up to tens of meters) for sonars and other transducers with higher source levels (within their hearing range); however, specific ranges cannot be provided in an unclassified document.

3.5.2.1.2.3 Impacts from Sonar and Other Transducers Under the Alternative 1

Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training and testing activities under Alternative 1 are described in Section 3.0.1.2.4.1 (Sonar and Other Transducers). 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). Low-frequency sources are operated more frequently during testing activities than during training activities. Although the general impacts from sonar and other transducers during testing would be similar in severity to those described during training, there may be slightly more impacts during testing activities as sea turtles can detect low frequency sources.

Under Alternative 1, training and testing activities would fluctuate each year to account for the natural variation of training cycles and deployment schedules. Training and testing activities, including low-frequency sonars within sea turtle hearing range (<2 kHz), could take place throughout the Study Area.

The quantitative analysis, using the number of hours of sonar and other transducers for a maximum year of training activities under Alternative 1, predicts that no sea turtles of any species are likely to be exposed to the high received levels of sound from sonars or other transducers that could cause TTS or PTS. Exposures were only modeled for green, hawksbill, leatherback, and loggerhead sea turtles in the Study Area and transit corridor. Olive ridley sea turtle presence in the Study Area is limited, and density data does not exist due to low occurrence in this region. Only a limited number of sonars and other transducers with frequencies within the range of sea turtle hearing (<2 kHz) and high source levels have the potential to cause TTS and PTS.

The *ANSI Sound Exposure Guidelines* estimate that the risk of a sea turtle responding to a low-frequency sonar (less than 1 kHz) is low regardless of proximity to the source, and that there is no risk of a sea turtle responding to a mid-frequency sonar (1–10 kHz) (Popper et al., 2014). A sea turtle could respond to sounds detected within their limited hearing range if they are close enough to the source. The few studies of sea turtle reactions to sounds, discussed in Section 3.5.2.1.1.5 (Behavioral Reactions), suggest that a behavioral response could consist of temporary avoidance, increased swim speed, or changes in depth, or that there may be no observable response. Use of sonar and other transducers would typically be transient and temporary and there is no evidence to suggest that any behavioral response would persist after a sound exposure. It is assumed that a stress response could accompany any behavioral response.

Implementation of mitigation may further reduce the already low risk of auditory impacts on sea turtles. Depending on the sonar source, mitigation includes powering down the sonar or ceasing active sonar transmission if a sea turtle is observed in the mitigation zone, as discussed in Section 3.5.2.1.2.1 (Methods for Analyzing Impacts from Sonar and Other Transducers – Accounting for Mitigation).

Although masking of biologically relevant sounds by the limited number of sonars and other transducers operated in sea turtle hearing range is possible, this may only occur in certain circumstances. Sea turtles most likely use sound to detect nearby broadband, continuous environmental sounds, such as the sounds of waves crashing on the beach. The use characteristics of low-frequency active sonars, including limited band width, beam directionality, limited beam width, relatively low source levels, low duty cycle, and limited duration of use, would both greatly limit the potential for a sea turtle to detect these sources and limit the potential for masking of broadband, continuous environmental sounds. In addition, broadband sources within sea turtle hearing range, such as countermeasures used during anti-submarine warfare, would typically be used in off-shore areas, not in near-shore areas where detection of beaches or concentrated vessel traffic is relevant.

Considering the above factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences to sea turtle individuals or populations would not be expected.

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 green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles.

3.5.2.1.2.4 Impacts from Sonar and Other Transducers Under Alternative 2 (Preferred Alternative)

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 under Alternative 2 are described in Section 3.0.1.2.4.1 (Sonar and Other Transducers). 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). Low-frequency sources are operated more frequently during testing activities than during training activities. Although the general impacts from sonar and other transducers during testing would be similar in severity to those described during training, there may be slightly more impacts during testing activities as sea turtles can detect low frequency sources.

Under Alternative 2, the same type and tempo of training and testing activities could occur as Alternative 1, but would include five Joint multi-strike group exercises (i.e., Valiant Shield) over five years as compared to three under Alternative 1. Additionally, Alternative 2 contemplates three (vice two) small joint coordinated anti-submarine warfare exercises (Multi-Sail/Guam Exercises) 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 sonar use 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.

The quantitative analysis predicts that no sea turtles of any species are likely to be exposed to the high received levels of sound from sonars or other transducers that could cause TTS or PTS during a maximum year of training activities under Alternative 2. Although there would be an increase in sonar use compared to Alternative 1, potential for and type of impacts on sea turtles would be the similar. This is because sea turtles are capable of detecting only a limited number of sonars due to their limited hearing range. Olive ridley sea turtle presence in the Study Area is limited and density data does not exist due to low occurrence in this region. Therefore, exposures were only modeled for green, hawksbill, leatherback, and loggerhead sea turtles in the Study Area and transit corridor. The NMFS's 2015 Biological Opinion (National Oceanic and Atmospheric Administration, 2015) on training and testing activities analyzed in the 2015 MITT Final EIS/OEIS considered sonars and other transducers to result in take incidental to military activities for green and hawksbill sea turtles.

Considering the above factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences to sea turtle individuals or populations would not be expected.

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 green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.1.2.5 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. Sonar and other transducers as listed above would not be introduced into the marine environment. 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 acoustic 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 lessen the potential for acoustics stressors on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.1.3 Impacts from Vessel Noise

Sea turtles may be exposed to noise from vessel movement. A detailed description of the acoustic characteristics and typical sound levels of vessel noise is 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 and 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).

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 Tables 2.5-1 and 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 (e.g., vessel noise) as listed above would not be introduced into the marine environment. 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 acoustic 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 lessen the potential for vessel noise impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

Pursuant to the ESA, vessel noise during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed green, hawksbill, leatherback, loggerhead and olive ridley sea turtles. The Navy is consulting on the activities described under Alternative 2 with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.1.4 Impacts from Aircraft Noise

Sea turtles may be exposed to aircraft-generated noise throughout the Study Area. Fixed- and rotary-wing aircraft are used during a variety of training and testing activities throughout the Study Area. Tilt-rotor impacts would be similar to fixed-wing or helicopter impacts, depending on the aircraft's mode. 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 (helicopters) produce low-frequency sound and vibration (Pepper et al., 2003).

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 Tables 2.5-1 and 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 (e.g., aircraft noise) as listed above would not be introduced into the marine environment. 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 acoustic 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 lessen the potential for aircraft noise impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

Pursuant to the ESA, aircraft noise during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed green, hawksbill, leatherback, loggerhead and olive ridley sea turtles. The Navy is consulting on the activities described under Alternative 2 with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.1.5 Impacts from Weapon Noise

Sea turtles may be exposed to sounds caused by the firing of weapons, objects in flight, and 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.

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 Tables 2.5-1 and 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. Implementation of mitigation may further reduce the already low risk of auditory impacts on sea turtles from weapon noise during large-caliber gunnery events, 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. Acoustic stressors (e.g., weapon noise) as listed above would not be introduced into the marine environment. 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 acoustic 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 lessen the potential for weapon noise impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

Pursuant to the ESA, weapon noise during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed green, hawksbill, leatherback, loggerhead and olive ridley sea turtles. The Navy is consulting on the activities described under Alternative 2 with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.2 Explosive Stressors

Explosions in the water or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. Unlike other acoustic stressors, explosives release energy at a high rate producing a shock wave that can be injurious and even deadly. Therefore, explosive impacts on sea turtles are discussed separately from other acoustic stressors, even though the analysis of explosive impacts will rely on data for sea turtle impacts due to impulsive sound exposure where appropriate.

Explosives are usually described by their net explosive weight, which accounts for the weight and type of explosive material. Additional explanation of the acoustic and explosive terms and sound energy concepts used in this section is found in Appendix H (Acoustic and Explosive Concepts).

This section begins with a summary of relevant data regarding explosive impacts on sea turtles in Section 3.5.2.2.1 (Background). 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), and this section follows that framework. Studies of the effects of sound and explosives on sea turtles are limited; therefore, where necessary, knowledge of impacts on other species from explosives is used to assess impacts on sea turtles.

Due to new acoustic impact criteria, sea turtle densities, and acoustics effects model, the analysis provided in Section 3.5.2.2.2 (Impacts from Explosives) of this SEIS/OEIS will supplant the 2015 MITT Final EIS/OEIS for sea turtles, and may result in changes to estimated impacts for some species since the 2015 MITT Final EIS/OEIS.

3.5.2.2.1 Background

The sections below include a survey and synthesis of best available science published in peer-reviewed journals, technical reports, and other scientific sources pertinent to impacts on sea turtles potentially resulting from Navy training and testing activities. Sea turtles could be exposed to a range of impacts depending on the explosive source and context of the exposure. In addition to acoustic impacts including temporary or permanent hearing loss, auditory masking, physiological stress, or changes in behavior; potential impacts from an explosive exposure can include non-lethal injury and mortality.

3.5.2.2.1.1 Injury

Because direct studies of explosive impacts on sea turtles have not been conducted, the below discussion of injurious effects is based on studies of other animals, generally mammals. The generalizations that can be made about in-water explosive injuries to other species should be applicable to sea turtles, with consideration of the unique anatomy of sea turtles. For example, it is unknown if the sea turtle shell may afford it some protection from internal injury.

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. However, rapid under-pressure phase caused by the negative surface-reflected pressure wave above an underwater detonation may create a zone of cavitation that may contribute to potential injury. In general, blast injury 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.

Primary blast injury is injury that results from the compression of a body exposed to a blast wave. This 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 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 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. In this discussion, primary blast injury to auditory tissues is considered gross structural tissue injury distinct from noise-induced hearing loss, which is considered below in Section 3.5.2.2.1.2 (Hearing Loss).

Data on observed injuries to sea turtles from explosives is generally limited to animals found following explosive removal of offshore structures (Viada et al., 2008), which can attract sea turtles for feeding opportunities or shelter. Klima et al. (1988) observed a turtle mortality subsequent to an oil platform removal blast, although sufficient information was not available to determine the animal's exposure. Klima et al. (1988) also placed small sea turtles (less than 7 kilograms) at varying distances from piling detonations. Some of the turtles were immediately knocked unconscious or exhibited vasodilation over the following weeks, but others at the same exposure distance exhibited no effects.

Incidental injuries to sea turtles due to a military explosion have been documented in a few instances. In one incident, a single 1,200-pound (lb.) trinitrotoluene (TNT) underwater charge was detonated off Panama City, FL in 1981. The charge was detonated at a mid-water depth of 120 feet (ft.). Although details are limited, the following were recorded: at a distance of 500–700 ft., a 400 lb. sea turtle was killed; at 1,200 ft., a 200–300 lb. sea turtle experienced "minor" injury; and at 2,000 ft. a 200–300 lb. sea turtle was not injured (O'Keeffe & Young, 1984). In another incident, two "immature" green sea turtles (size unspecified) were found dead about 100-150 ft. away from detonation of 20 lb. of C-4 in a shallow water environment.

Results from limited experimental data suggest two explosive metrics are predictive of explosive injury: peak pressure and impulse.

Impulse as a Predictor of Explosive Injury

Without measurements of the explosive exposures in the above incidents, it is difficult to draw conclusions about what amount of explosive exposure would be injurious to sea turtles. Studies of observed in-water explosive injuries showed that terrestrial mammals were more susceptible than comparably sized fish with swim bladders (Yelverton & Richmond, 1981), and that fish with swim bladders may have increased susceptibility to swim bladder oscillation injury depending on exposure geometry (Goertner, 1978; Wiley et al., 1981). Therefore, controlled tests with a variety of terrestrial mammals (mice, rats, dogs, pigs, sheep and other species) are the best available data sources on actual injury to similar-sized animals 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 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 principle damage sites in submerged terrestrial mammals, consistent with earlier studies of mammal exposures to underwater explosions (Clark & Ward, 1943; Greaves et al., 1943).

In the Lovelace studies, acoustic impulse was found to be the metric most related to degree of injury, and size of an animal's gas-containing cavities was thought to play a role in blast injury susceptibility. The proportion of lung volume to overall body size is similar between sea turtles and terrestrial mammals, so the magnitude of lung damage in the tests may approximate the magnitude of injury to sea turtles when scaled for body size. Measurements of some shallower diving sea turtles (Hochscheid et al., 2007) show lung-to-body size ratios that are larger than terrestrial animals, whereas the lung-to-body mass ratio of the deeper diving leatherback sea turtle is smaller (Lutcavage et al., 1992). 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 kilograms) to underwater detonations, Richmond et al. (1973) reported that no blast injuries were observed when exposures were less than 6 lb. per square inch (in.) per millisecond (psi-ms) (40 pascal-seconds [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 adult sea turtles may be substantially 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 size and depth in a bubble oscillation model of the lung, which is assumed to be applicable to sea turtles as well for this analysis. 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 time 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. Based on a study of green sea turtles, Berkson (1967) predicted sea turtle lung collapse would be complete around 80–160 meter depth.

Peak Pressure as a Predictor of Explosive Trauma

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 lb. psi (237 dB re 1 μPa peak) to feel like a 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 1,147 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.

The *ANSI Sound Exposure Guidelines* (Popper et al., 2014) recommended peak pressure guidelines for sea turtle injury from explosives. Lacking any direct data for sea turtles, these recommendations were based on fish data. Of the fish data available, the working group conservatively chose the study with the lowest peak pressures associated with fish mortality to set guidelines (Hubbs & Rechnitzer, 1952), and did not consider the Lovelace studies discussed above.

3.5.2.2.1.2 Hearing Loss

An underwater explosion produces broadband, impulsive sound that can cause noise-induced hearing loss, typically quantified as threshold shift, which persists after cessation of the noise exposure. This noise-induced hearing loss may manifest as TTS or PTS. Because studies on inducing threshold shift in sea turtles are very limited (e.g., alligator lizards: Dew et al., 1993; Henry & Mulroy, 1995) and have not been conducted on any of the sea turtles present in the Study Area, auditory threshold shift in sea turtles is considered to be consistent with general knowledge about noise-induced hearing loss described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

Little is known about how sea turtles use sound in their environment. The *ANSI Sound Exposure Guidelines* (Popper et al., 2014) do not suggest numeric sound exposure thresholds for auditory effects on sea turtles due to lack of data. Rather, the guidelines qualitatively advise that sea turtles are less likely to incur TTS or PTS with increasing distance from an explosive. The guidelines also suggest that data from fishes may be more relevant than data from marine mammals when estimating auditory impacts on sea turtles, because, in general, fish hearing range is more similar to the limited hearing range of sea turtles. As shown in Section 3.5.1.4 (Hearing and Vocalization), sea turtle hearing is most sensitive around 100–400 Hz in-water, is limited over 1 kHz, and is much less sensitive than that of any marine mammal.

3.5.2.2.1.3 Physiological Stress

A stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. If the magnitude and duration of the stress response is too great or too long, it can have negative consequences to the animal (e.g. decreased immune function, decreased reproduction). Physiological stress is typically analyzed by measuring stress hormones, other biochemical markers, or vital signs. Physiological stress has been measured for sea turtles during nesting (Flower et al., 2015; Valverde et al., 1999) and capture and handling (Flower et al., 2015; Gregory & Schmid, 2001), but the stress caused by acoustic exposure has not been studied for sea turtles. Therefore, the stress response in sea turtles in the Study Area due to acoustic exposures is considered to be consistent with general knowledge about physiological stress responses described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

Marine animals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, nesting, and interactions with predators all contribute to stress. Anthropogenic sound-producing activities have the potential to provide additional stressors beyond those that naturally occur.

Due to the limited information about acoustically induced stress responses, the Navy conservatively assumes in its effect analysis that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

3.5.2.2.1.4 Masking

As described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), auditory masking occurs when one sound, distinguished as the “noise,” interferes with the detection or recognition of another sound or limits the distance over which other biologically relevant sounds can be detected. Masking only occurs when the sound source is operating; therefore, direct masking effects stop immediately upon cessation of the sound-producing activity. Any unwanted sound above ambient noise and within an animal's hearing range may potentially cause masking which can interfere with an animal's ability to detect, understand, or recognize biologically relevant sounds of interest.

Masking occurs in all vertebrate groups and can effectively limit the distance over which an animal can communicate and detect biologically relevant sounds. The effect of masking has not been studied for sea turtles. The potential for masking in sea turtles would be limited to certain sound exposures due to their limited hearing range to broadband low-frequency sounds and lower sensitivity to noise in the marine environment. Only continuous human-generated sounds that have a significant low-frequency component, are not of brief duration, and are of sufficient received level could create a meaningful masking situation. While explosives produce intense, broadband sounds with significant low-frequency content, these sounds are very brief with limited potential to mask relevant sounds.

There is evidence that sea turtles may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al., 2013) and magnetic orientation (Avens, 2003; Putman et al., 2015). Any effect of masking may be mediated by reliance on other environmental inputs.

3.5.2.2.1.5 Behavioral Reactions

There are no observations of behavioral reactions by sea turtles to exposure to explosive sounds. 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. Although explosive sources are more energetic than air guns, the few studies of sea turtle responses to air guns, which are not used during MITT training or testing activities, may show the types of behavioral responses that sea turtles may have towards explosives. General research findings regarding behavioral reactions from sea turtles due to exposure to impulsive sounds, such as those associated with explosions, are discussed in detail in Behavioral Reactions to Impulsive Sound Sources under Section 3.5.2.1 (Acoustic Stressors).

3.5.2.2.1.6 Long-Term Consequences

For sea turtles present in the Study Area, long-term consequences to individuals and populations due to acoustic exposures have not been studied. Therefore, long term consequences to sea turtles due to explosive exposures are considered following Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

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, which could impact navigation. The long-term consequences due to individual behavioral reactions and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies. 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 exposures to multiple stressors over significant periods of time. Conversely, some sea turtles may habituate to or become tolerant of repeated acoustic exposures over time, learning to ignore a stimulus that in the past did not accompany any overt threat. For example, loggerhead sea turtles exposed to air guns with a source SPL of 179 dB re 1 µPa initially exhibited avoidance reactions. However, they may have habituated to the sound source after multiple exposures since a habituation behavior was retained when exposures were separated by several days (Moein Bartol et al., 1995). More research is needed to better understand the long-term consequences of human-made noise on sea turtles, although intermittent exposures are assumed to be less likely to have lasting consequences.

3.5.2.2.2 Impacts from Explosives

Sea turtles could be exposed to energy, sound, and fragments from explosions in the water and near the water surface associated with the proposed activities. Energy and sound from an explosion are 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 may limit an animal's ability interpret the surrounding environment. Impairment of these abilities can decrease an individual's chance of survival or affect its ability to reproduce. Temporary threshold shift can also impair an animal's abilities, although the individual may recover quickly with little significant effect.

Overall, the locations, types, and severity of predicted impacts for the use of explosives during training and testing activities would be similar to what is currently conducted, with the addition of several new testing activities as described in Table 2.5-1. Although individual activities may vary in the number of events or ordnances some from those previously analyzed, the overall determinations presented in the 2015 MITT Final EIS/OEIS remain valid, and has been developed further under the current SEIS/EIS.

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, 2018).

3.5.2.2.2.1 Methods for Analyzing Impacts from Explosives

Potential impacts considered are mortality, injury, hearing loss due to threshold shift (permanent or temporary), masking of other biologically relevant sounds, physiological stress, and changes in behavior.

The Navy's quantitative analysis to determine impacts on sea turtles and marine mammals uses the Navy Acoustic Effects Model to produce initial estimates of the number of times these animals may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation. 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 sea turtles, and
- 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 further detailed explanation of this analysis is provided in the technical report titled *Quantitative Analysis for Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018).

Criteria and Thresholds used to Predict Impacts on Sea Turtles from Explosives

Mortality and Injury from Explosives

As discussed above in Section 3.5.2.2.1.1 (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).

Two sets of thresholds 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 3.5-2). The thresholds for the farthest range to effect are based on the received level at which 1 percent risk is predicted and are useful for assessing potential effects to sea turtles and marine mammals, and the range at which mitigation could be effective. 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, sea turtle populations are assumed to be 5 percent adult and 95 percent sub-adult. This adult to sub-adult population ratio is estimated from what is known about the population age structure for sea turtles. Sea turtles typically lay multiple clutches of 100 or more eggs with little parental investment and generally have low survival in early life. However, sea turtles that are able to survive past early life generally have high age-specific survival in later life.

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 3.5-2: Criteria to Quantitatively Assess Non-Auditory Injury due to Underwater Explosions

Impact Category	*Exposure Threshold*	*Threshold for Farthest Range to Effect*
Mortality[1]	$144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s	$103M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ 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 1 percent risk used to assess mitigation effectiveness.

Note: dB re 1 µPa = decibels referenced to 1 micropascal, SPL = sound pressure level, M = animal mass (kg), D = animal depth (m), and Pa-s = Pascal-second

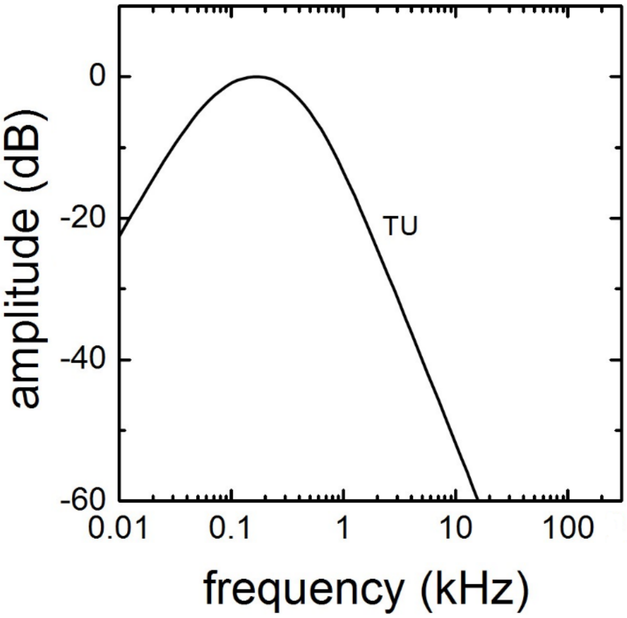
When explosive munitions (e.g., a bomb or missile) detonates, fragments of the weapon are thrown at high-velocity from the detonation point, which can injure or kill sea turtles if they are struck. Risk of fragment injury reduces exponentially with distance as the fragment density is reduced. Fragments 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.

Fragments produced by exploding munitions at or near the surface may present a high-speed strike hazard for an animal at or near the surface. In water, however, fragmentation velocities decrease rapidly due to drag (Swisdak & Montanaro, 1992). Because blast waves propagate efficiently through water, the range to injury from the blast wave would likely extend beyond the range of fragmentation risk.

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. 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. The adjusted received sound level is referred to as a weighted received sound level.

The auditory weighting function for sea turtles is shown in Figure 3.5-6. The derivation of this weighting function is described 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). The frequencies around the top portion of the function, where the amplitude is closest to zero, are emphasized, while the frequencies below and above this range (where amplitude declines) are de-emphasized, when summing acoustic energy received by a sea turtle.



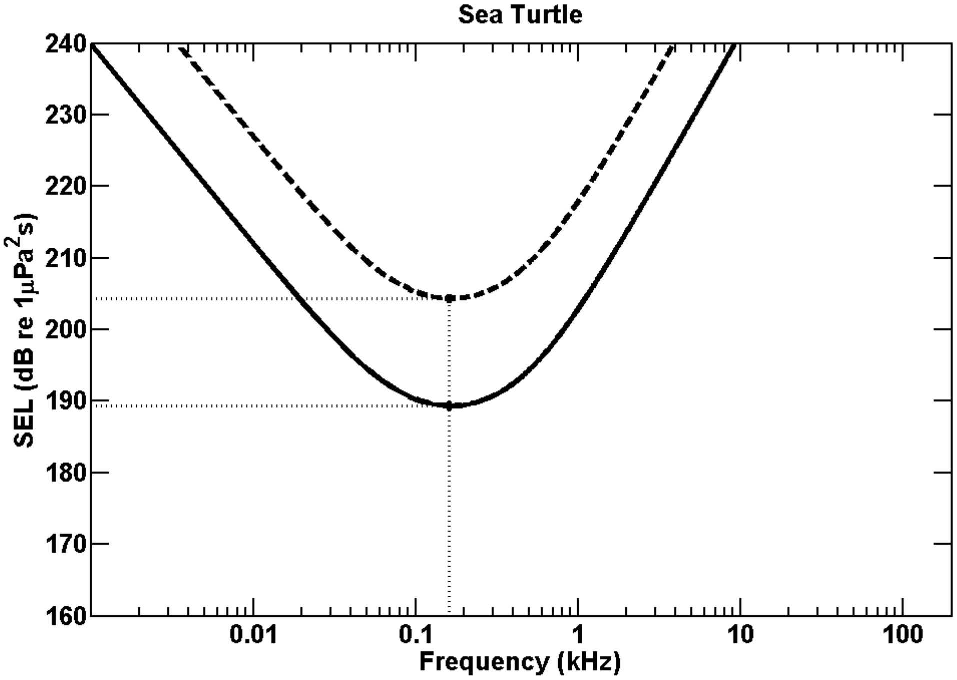
Source: U.S. Department of the Navy (2017a)
Notes: dB = decibels, kHz = kilohertz, TU = sea turtle hearing group

Figure 3.5-6: Auditory Weighting Functions for Sea Turtles

Hearing Loss from Explosives

No studies of hearing loss have been conducted on sea turtles. Therefore, sea turtle susceptibility to hearing loss due to an acoustic exposure is evaluated using knowledge about sea turtle hearing abilities in combination with non-impulsive auditory effect data from other species (marine mammals and fish). This yields sea turtle exposure functions, shown in Figure 3.5-7, which are mathematical functions that relate the SELs for onset of TTS or PTS to the frequency of the sonar sound exposure. The derivation of the sea turtle exposure functions 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).

For impulsive sounds, hearing loss in other species has also been observed to be related to the unweighted peak pressure of a received sound. Because this data does not exist for sea turtles, unweighted peak pressure thresholds for TTS and PTS were developed by applying relationships observed between impulsive peak pressure TTS thresholds and auditory sensitivity in marine mammals to sea turtles. This results in dual-metric hearing loss criteria for sea turtles for impulsive sound exposure: the SEL-based exposure functions in Figure 3.5-7 and the peak pressure thresholds in Table 3.5-3. The derivation of the sea turtle impulsive peak pressure TTS and PTS thresholds 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).



Notes: kHz = kilohertz, SEL = Sound Exposure Level, dB re 1 μPa^{2}s = decibels referenced to 1 micropascal squared second. The solid black curve is the exposure function for TTS onset and the dashed black curve is the exposure function for PTS onset. Small dashed lines and asterisks indicate the SEL thresholds and most sensitive frequency for TTS and PTS.

Figure 3.5-7: TTS and PTS Exposure Functions for Impulsive Sounds

Table 3.5-3: TTS and PTS Peak Pressure Thresholds Derived for Sea Turtles Exposed to Impulsive Sounds

Auditory Effect	***Unweighted Peak Pressure Threshold***
TTS	226 dB re 1 µPa SPL peak
PTS	232 dB re 1 µPa SPL peak

Notes: dB re 1 µPa = decibels referenced to 1 micropascal, PTS = permanent threshold shift, SPL = sound pressure level, TTS = temporary threshold shift

Accounting for Mitigation

The Navy will implement mitigation measures to avoid or reduce potential impacts from explosives on sea turtles, 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 sea turtle is observed in a mitigation zone. The mitigation zones for explosives extend beyond the respective average ranges to mortality. The mitigation zones encompass the estimated ranges to mortality for a given explosive. Therefore, the impact analysis quantifies the potential for 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., 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, 2017a).

In the quantitative analysis, consideration of mitigation measures means that, for activities where mitigation is feasible, model-estimated mortality is considered mitigated to the level of injury. 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 Navy will also implement mitigation measures for certain explosive activities within mitigation areas, including the Marpi Reef Mitigation Area, Chalan Kanoa Reef Mitigation Area, and Agat Bay Nearshore Mitigation Area, as described in Appendix I (Geographic Mitigation Assessment). Mitigation areas are designed to help avoid or reduce impacts during biologically important life processes within particularly important habitat areas. The benefits of mitigation areas are discussed qualitatively in terms of the context of impact avoidance or reduction.

3.5.2.2.2.2 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 3.5.2.2.2.1, Methods for Analyzing Impacts from Explosives). The range to effects is 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 would need to propagate to reach exposure level thresholds specific to a hearing group that would cause TTS, PTS, non-auditory injury, and mortality. 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 will likely be mitigated within applicable mitigation zones.

Table 3.5-4 shows the minimum, average, and maximum ranges due to varying propagation conditions to non-auditory injury based on the larger of the range to slight lung injury or gastrointestinal tract injury for representative animal masses ranging from 10 to 1,000 kilograms and different explosive bins ranging from 0.25 to 1,000 lb. net explosive weight. 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 3.5-5.

The following tables (Table 3.5-6 and Table 3.5-7) show the minimum, average, and maximum ranges to onset of auditory and behavioral effects based on the thresholds described in Section 3.5.2.2.2.1 (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 Ranges* (U.S. Department of the Navy, 2017b).

Table 3.5-4: Ranges to Non-Auditory Injury[1] (in meters) for Sea Turtles Exposed to Explosives as a Function of Animal Mass

Bin[2]	*Range to Non-Auditory Injury (meters) for Various Animal Mass Intervals (kg)* [1]		
	10 kg	***250 kg***	***1,000 kg***
E1	12 (11–13)	12 (11–13)	12 (11–13)
E2	16 (15–16)	16 (15–16)	16 (15–16)
E3	25 (25–25)	25 (25–25)	25 (25–25)
E4	30 (30–35)	30 (30–35)	30 (30–35)
E5	40 (40–65)	40 (40–50)	40 (40–50)
E6	52 (50–60)	52 (50–55)	52 (50–55)
E8	93 (90–150)	91 (90–95)	91 (90–95)
E9	123 (120–270)	123 (120–140)	123 (120–130)
E10	155 (150–420)	155 (150–240)	155 (150–160)
E11	398 (380–420)	219 (170–260)	172 (160–220)
E12	195 (190–650)	195 (190–380)	195 (190–200)

[1] Average distance (m) to non-auditory injury is depicted above the minimum and maximum distances which are in parentheses. The ranges depicted are the further of the ranges for gastrointestinal tract injury or slight lung injury for an explosive bin and animal mass interval combination.

[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).

Table 3.5-5: Ranges to Mortality for Sea Turtles Exposed to Explosives as a Function of Animal Mass[1]

Bin	*Ranges to Mortality (meters) for Various Animal Mass Intervals (kg)*[1]		
	10 kg	***250 kg***	***1,000 kg***
E1	2 (2–3)	1 (0–1)	0 (0–0)
E2	4 (3–4)	1 (1–2)	1 (1–1)
E3	8 (6–9)	4 (3–6)	2 (2–2)
E4	13 (11–15)	7 (5–9)	4 (4–5)
E5	12 (11–30)	7 (5–18)	4 (4–7)
E6	15 (14–25)	9 (7–17)	5 (5–9)
E8	40 (24–65)	22 (12–40)	14 (9–21)
E9	31 (30–35)	20 (16–24)	13 (12–13)
E10	54 (40–170)	24 (20–25)	16 (15–17)
E11	194 (180–210)	96 (70–130)	53 (50–55)
E12	83 (50–260)	31 (25–90)	20 (19–20)

[1] Average distance (m) to mortality is depicted above the minimum and maximum distances which are in parentheses.

[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).

Table 3.5-6: Peak Pressure Based Ranges to TTS and PTS for Sea Turtles Exposed to Explosives

Range to Effects for Explosives: Sea turtles[1]				
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	1	35 (35–35)	68 (65–70)
		18	35 (35–35)	68 (65–70)
E2	0.1	1	48 (45–50)	87 (80–90)
		5	48 (45–50)	87 (80–90)
E3	0.1	1	81 (75–85)	145 (140–150)
		12	81 (75–85)	145 (140–150)
	18.25	1	80 (80–80)	150 (150–150)
		12	80 (80–80)	150 (150–150)
E4	10	2	100 (100–100)	192 (190–200)
	60	2	101 (100–110)	194 (190–220)
E5	0.1	20	125 (120–130)	235 (230–250)
	30	20	138 (130–160)	257 (240–290)
E6	0.1	1	163 (160–170)	292 (270–320)
	30	1	160 (160–160)	300 (300–300)
E8	0.1	1	273 (260–280)	451 (370–500)
	45.75	1	281 (280–300)	527 (525–575)
E9	0.1	1	355 (320–380)	566 (440–675)

Table 3.5-6: Peak Pressure Based Ranges to TTS and PTS for Sea Turtles Exposed to Explosives (continued)

Range to Effects for Explosives: Sea turtles[1]				
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***
E10	0.1	1	432 (360–550)	690 (480–1,025)
E11	45.75	1	540 (525–625)	977 (950–1,025)
	91.4	1	558 (500–800)	1,053 (825–2,025)
E12	0.1	1	509 (410–575)	784 (550–1,025)
		4	509 (410–575)	784 (550–1,025)

[1]Average distance (m) to TTS and PTS are depicted above the minimum and maximum distances which are in parentheses. Values depict ranges to TTS and PTS based on the peak pressure metric.

[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).

Table 3.5-7: SEL Based Ranges to TTS and PTS for Sea Turtles Exposed to Explosives

Range to Effects for Explosives: Sea turtles[1]				
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	1	0 (0–0)	0 (0–0)
		18	0 (0–0)	2 (2–2)
E2	0.1	1	0 (0–0)	1 (1–1)
		5	0 (0–0)	2 (2–2)
E3	0.1	1	0 (0–0)	3 (2–3)
		12	2 (1–2)	8 (8–18)
	18.25	1	3 (3–3)	17 (16–17)
		12	10 (10–10)	70 (70–70)

Table 3.5-7: SEL Based Ranges to TTS and PTS for Sea Turtles Exposed to Explosives (continued)

Range to Effects for Explosives: Sea turtles[1]				
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***
E4	10	2	7 (7–8)	52 (50–55)
	60	2	7 (7–7)	35 (35–35)
E5	0.1	20	5 (5–5)	36 (25–270)
	30	20	48 (40–65)	293 (240–400)
E6	0.1	1	2 (2–2)	10 (10–180)
	30	1	14 (14–14)	95 (95–95)
E8	0.1	1	5 (5–5)	39 (25–290)
	45.75	1	40 (40–40)	271 (270–280)
E9	0.1	1	9 (9–9)	87 (40–410)
E10	0.1	1	13 (13–270)	164 (60–1,000)
E11	45.75	1	170 (170–180)	832 (750–850)
	91.4	1	150 (150–170)	794 (750–875)
E12	0.1	1	31 (18–120)	200 (80–950)
		4	59 (30–380)	377 (140–5,025)

[1] Average distance (m) to TTS and PTS are depicted above the minimum and maximum distances which are in parentheses. Values depict ranges to TTS and PTS based on the SEL metric.

[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).

3.5.2.2.2.3 Presentation of Estimated Impacts from the Quantitative Analysis

The results of the analysis of potential impacts to sea turtles from explosives as described in Section 3.5.2.2.2.1 (Methods for Analyzing Impacts from Explosives) are discussed below. Estimated numbers of potential impacts from the quantitative analysis for sea turtles are presented below. The most likely regions and activity categories from which the impacts could occur are displayed in the figures. There is a potential for impacts to occur anywhere within the Study Area where sound and energy from explosives and the species overlap, although only areas or categories where 0.5 percent of the impact, or greater, are estimated to occur are graphically represented on the species-specific figures below. All (i.e., grand total) estimated impacts are included in the graphics, regardless of region or category.

The numbers of activities planned can vary slightly from year-to-year. Results are presented for a maximum explosive use year; however, during most years, explosive use would be less resulting in fewer potential impacts. The number of explosives used are described in Section 3.0.4.2 (Explosive Stressors).

Ranges to effect (see Table 3.5-4 through Table 3.5-7) were developed in the Navy Acoustic Effects Model based on the thresholds for TTS, PTS, injury, and mortality discussed above.

3.5.2.2.2.4 Impacts from Explosives Under Alternative 1

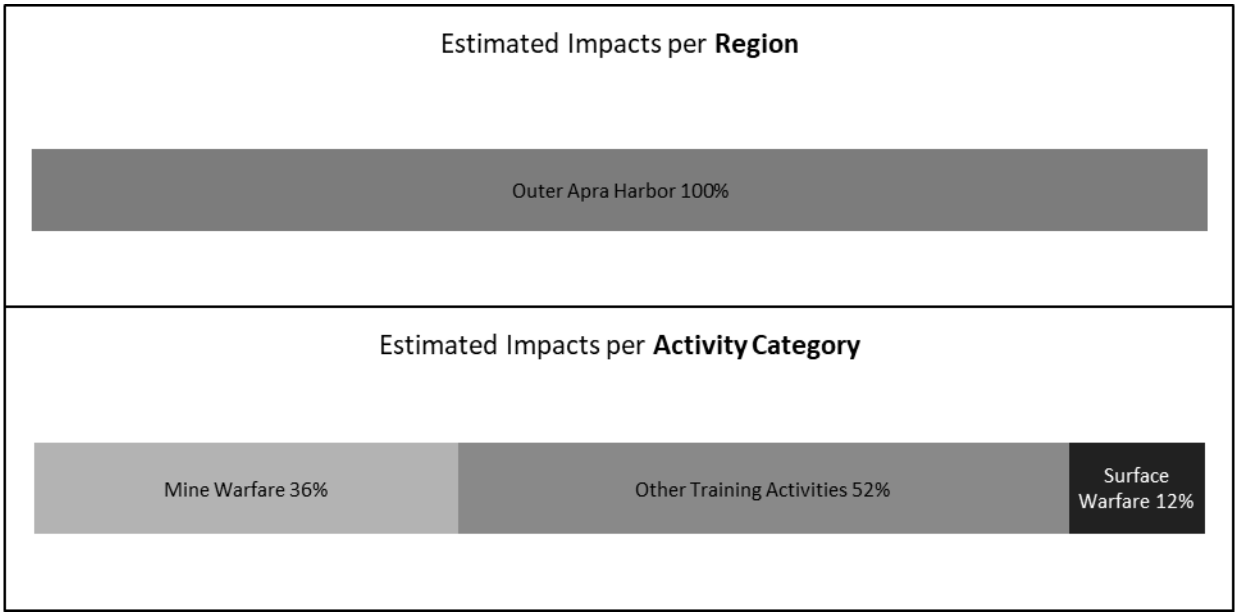
Activities using explosives would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Training and Testing Activities Descriptions). General characteristics, quantities, and net explosive weights of in-water explosives used during training and testing activities under Alternative 1 are provided in Section 3.0.4.2 (Explosive Stressors). Quantities and locations of fragment-producing explosives during training and testing activities under Alternative 1 are shown in 3.0.4.4.4 (Military Expended Materials).

Under Alternative 1, there could be fluctuation in the number of explosions 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 Tables 2.5-1 and 2.5-2.

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 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, as described in Section 3.0.4.2 (Explosive Stressors).

Detonations would typically occur in waters greater than 200 ft. in depth, and greater than 3 nautical miles from shore, with the exception of existing mine warfare areas, including Outer Apra Harbor, Piti, and Agat. Section 5.3.3 (Explosive Stressors) outlines the procedural mitigation measures for explosive stressors to reduce potential impacts on biological resources.

The quantitative analysis, using a maximum year of training and testing activities, estimates that no sea turtles would be killed, however, a small number of green sea turtles would be exposed to levels of explosive sound and energy in the outer Apra Harbor that could cause TTS or PTS (Table 3.5-8). The quantitative analysis predicts that no hawksbill, leatherback, or loggerhead sea turtles are likely to be exposed to the levels of explosive sound and energy that could cause TTS or PTS during training and testing activities under Alternative 1 (for impact tables, see Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Olive ridley sea turtle presence in the Study Area is limited and density data does not exist due to low occurrence in this region. Therefore, exposures were only modeled for green, hawksbill, leatherback, and loggerhead sea turtles in the Study Area and transit corridor. Fractional estimated impacts per region and activity area represent the probability that the number of estimated impacts by effect would occur in a certain region or be due to a certain activity category.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided up among multiple regions or activity categories.

Figure 3.5-8: Green Sea Turtle Estimated Impacts per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.5-8: Estimated Impacts on Individual Green Sea Turtles Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
TTS	*PTS*	*Injury*
6	3	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Threshold shifts and injuries could reduce the fitness of an individual animal, causing a reduction in foraging success, reproduction, or increased susceptibility to predators. This reduction in fitness would be temporary for recoverable impacts, such as TTS, but there could be long-term consequences to some individuals. However, no population-level impact is expected due to the low number of estimated injuries for any sea turtle species relative to total population size. This can also be assumed for olive ridley turtles if exposed to explosions.

As discussed in Section 5.3.3 (Explosive Stressors), procedural mitigation includes ceasing explosive detonations (e.g., ceasing deployment of an explosive bomb) if a sea turtle is observed in the mitigation zone whenever and wherever applicable activities occur. In addition to this procedural mitigation, the

Navy will implement mitigation to avoid or reduce impacts from explosions on seafloor resources in mitigation areas throughout the Study Area, as described in Section 5.4.1 (Mitigation Areas for Seafloor Resources). This will further reduce the potential for impacts on sea turtles that shelter and feed on shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks.

Sea turtle hearing is less sensitive than other marine mammals, and the role of their underwater hearing is unclear. Sea turtle's limited hearing range (<2 kHz) is most likely used to detect nearby broadband, continuous environmental sounds, such as the sounds of waves crashing on the beach, that may be important for identifying their habitat. Recovery from a hearing threshold shift begins almost immediately after the noise exposure ceases. A temporary threshold shift is expected to take a few minutes to a few days, depending on the severity of the initial shift, to fully recover (U.S. Department of the Navy, 2017a). If any hearing loss remains after recovery, that remaining hearing threshold shift is permanent. Because explosions produce broadband sounds with low-frequency content, hearing loss due to explosive sound could occur across a sea turtle's very limited hearing range, reducing the distance over which relevant sounds, such as beach sounds, may be detected for the duration of the threshold shift.

Some sea turtles may behaviorally respond to the sound of an explosive. A sea turtle's behavioral response to a single detonation or explosive cluster is expected to be limited to a short-term (seconds to minutes) startle response, as the duration of noise from these events is very brief. Limited research and observations from air gun studies (See Section 3.5.2.2.2.1, Methods for Analyzing Impacts from Explosives) suggest that if sea turtles are exposed to repetitive impulsive sounds in close proximity, they may react by increasing swim speed, avoiding the source, or changing their position in the water column. There is no evidence to suggest that any behavioral response would persist beyond the sound exposure. Because the duration of most explosive events is brief, the potential for masking is low. The *ANSI Sound Exposure Guidelines* (Popper et al., 2014) consider masking to not be a concern for sea turtles exposed to explosions.

A physiological stress response is assumed to accompany any injury, hearing loss, or behavioral reaction. A stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. While the stress response is a normal function for an animal dealing with natural stressors in their environment, chronic stress responses could reduce an individual's fitness. Due to the low number of estimated impacts, it is not likely that any sea turtle would experience repeated stress responses due to explosive impacts.

Pursuant to the ESA, use of explosives during training and testing activities as described under Alternative 1 may affect ESA-listed green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles.

3.5.2.2.2.5 Impacts from Explosives Under Alternative 2 (Preferred Alternative)

Activities using explosives would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Training and Testing Activities Descriptions). General characteristics, quantities, and net explosive weights of in-water explosives used during training under Alternative 2 are provided in Section 3.0.4.2 (Explosive Stressors). Quantities and locations of fragment-producing explosives during training under Alternative 2 are shown in 3.0.4.4.4 (Military Expended Materials).

Under Alternative 2, there could be fluctuation in the amount of explosions 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 Tables 2.5-1 and 2.5-2.

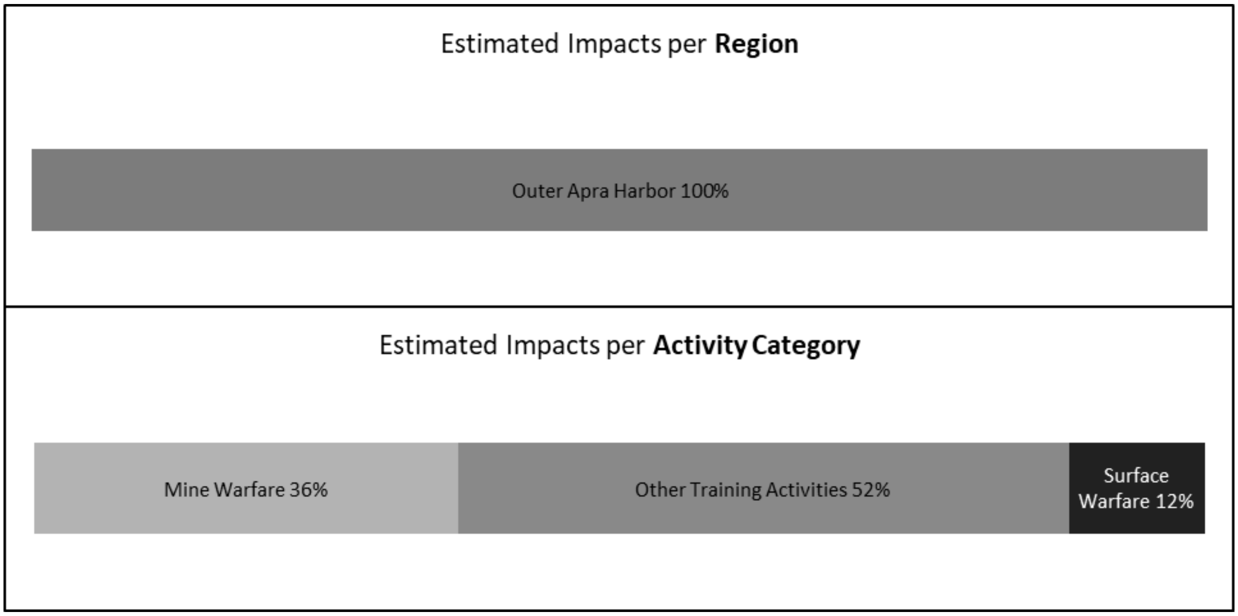
The numbers of activities planned under Alternative 2 are consistent from year-to-year and would increase slightly compared to activities planned under Alternative 1. The numbers of explosives used under each alternative are described in Section 3.0.4.2 (Explosive Stressors).

Under Alternative 2, it is possible that impacts would be slightly increased in some years, as explosive use would fluctuate. The quantitative analysis, using a maximum year of training and testing activities, estimates that no sea turtles would be killed, however, a small number of green sea turtles would be exposed to levels of explosive sound and energy in the outer Apra Harbor that could cause TTS or PTS (Table 3.5-9). The quantitative analysis predicts that no hawksbill, leatherback, or loggerhead sea turtles are likely to be exposed to the levels of explosive sound and energy that could cause TTS, PTS, or injury during training and testing activities under Alternative 2. Olive ridley sea turtle presence in the Study Area is limited and density data does not exist due to low occurrence in this region. Therefore, exposures were only modeled for green, hawksbill, leatherback, and loggerhead sea turtles in the Study Area and transit corridor. Fractional estimated impacts per region and activity area represent the probability that the number of estimated impacts by effect would occur in a certain region or be due to a certain activity category.

Threshold shifts and injuries could reduce the fitness of an individual animal, causing a reduction in foraging success, reproduction, or increased susceptibility to predators. This reduction in fitness would be temporary for recoverable impacts, such as TTS, but there could be long-term consequences to some individuals. However, no population-level impact is expected due to the low number of estimated injuries for any sea turtle species relative to total population size. This can also be assumed for olive ridley turtles exposed to explosions.

As discussed in Section 5.3.3 (Explosive Stressors), procedural mitigation includes ceasing explosive detonations (e.g., ceasing deployment of an explosive bomb) if a sea turtle is observed in the mitigation zone whenever and wherever applicable activities occur. In addition to this procedural mitigation, the Navy will implement mitigation to avoid or reduce impacts from explosions on seafloor resources in mitigation areas throughout the Study Area, as described in Section 5.4.1 (Mitigation Areas for Seafloor Resources). This would further reduce the potential for impacts on sea turtles that shelter and feed on shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks.

Sea turtle hearing is less sensitive than other marine animals (i.e., marine mammals), and the role of their underwater hearing is unclear. Sea turtle's limited hearing range (<2 kHz) is most likely used to detect nearby broadband, continuous environmental sounds, such as the sounds of waves crashing on the beach, that may be important for identifying their habitat. Recovery from a hearing threshold shift begins almost immediately after the noise exposure ceases. A temporary threshold shift is expected to take a few minutes to a few days, depending on the severity of the initial shift, to fully recover (U.S. Department of the Navy, 2017a). If any hearing loss remains after recovery, that remaining hearing threshold shift is permanent. Because explosions produce broadband sounds with low-frequency content, hearing loss due to explosive sound could occur across a sea turtle's very limited hearing range, reducing the distance over which relevant sounds, such as beach sounds, may be detected for the duration of the threshold shift.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided up among multiple regions or activity categories.

Figure 3.5-9: Green Sea Turtle Impacts Estimated per Year from Explosions During Training and Testing Under Alternative 2

Table 3.5-9: Estimated Impacts on Individual Green Sea Turtles Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
TTS	***PTS***	***Injury***
6	3	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Some sea turtles may behaviorally respond to the sound of an explosive. A sea turtle's behavioral response to a single detonation or explosive cluster is expected to be limited to a short-term (seconds to minutes) startle response, as the duration of noise from these events is very brief. Limited research and observations from air gun studies suggest that if sea turtles are exposed to repetitive impulsive sounds in close proximity, they may react by increasing swim speed, avoiding the source, or changing their position in the water column. There is no evidence to suggest that any behavioral response would persist beyond the sound exposure. Because the duration of most explosive events is brief, the potential for masking is low. The *ANSI Sound Exposure Guidelines* (Popper et al., 2014) consider masking to not be a concern for sea turtles exposed to explosions.

A physiological stress response is assumed to accompany any injury, hearing loss, or behavioral reaction. A stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. While the stress response is a normal function for an animal dealing with natural stressors in their environment, chronic stress responses could reduce an individual's fitness. Due to the low number of estimated impacts, it is not likely that any sea turtle would experience repeated stress responses due to explosive impacts.

Pursuant to the ESA, use of explosives during training and testing activities as described under Alternative 2 may affect ESA-listed green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.2.2.6 Impacts from Explosives 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. Explosives stressors (e.g., explosive shock wave and sound, explosive fragments) as listed above would not be introduced into the marine environment. 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 explosive 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 lessen the potential for explosive impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.3 Energy Stressors

This section analyzes the potential impacts of the various types of energy stressors that can occur during training and testing activities within the Study Area. This section includes analysis of the potential effects of (1) in-water electromagnetic devices, and (2) high-energy lasers on sea turtles within the Study Area. Energy stressors are discussed in Section 3.0.4.3.

Energy stressors that may impact sea turtles include in-water electromagnetic devices and high-energy lasers. 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 animals (Brothers & Lohmann, 2015; Endres et al., 2016; Gill et al., 2014; Kremers et al., 2014; Kremers et al., 2016; Putman et al., 2015; Zellar et al., 2017). There is no new information that changes the basis of the conclusion. 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. While the number of training and testing activities using in-water electromagnetic devices would change under this SEIS/OEIS, the analysis presented in the 2015 MITT Final EIS/OEIS, Section 3.5.4.3 (Energy Stressors), and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Marine Fisheries Service, 2015b) remains valid for in-water electromagnetic devices.

High-energy laser use was not covered in the 2015 MITT Final EIS/OEIS and represents a new activity analyzed in this SEIS/OEIS. The primary concern is the potential for a sea turtle to be exposed to the laser beam at or near the water’s surface, which could result in injury or death. However, sea turtles could only be exposed if the laser beam missed the target. As discussed in Section 3.0.4.3.2.2 (High-Energy Lasers), if there is a miss from a boat target, the laser beam may strike the water in the 200 meters (219 yards) to 6.5 kilometers (7,108 yards) range or more, assuming an engagement range of 200–5,000 meters. At these ranges, the low angles to the water will reflect most of the laser energy, and sea turtles would only be exposed if they were in the same exact position as the laser beam on the surface.

3.5.2.3.1 Impacts from In-Water Electromagnetic Devices 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 (Table 3.0-9). The activities would occur in the same locations and in a similar manner as were analyzed previously.

Therefore, impacts on sea turtles under Alternative 1 from energy stressors, including in-water electromagnetic devices, would be negligible.

Pursuant to the ESA, the use of in-water electromagnetic devices during training and testing activities as described under Alternative 1 would have no effect on ESA-listed sea turtles.

3.5.2.3.2 Impacts from In-Water Electromagnetic Devices Under Alternative 2 (Preferred Alternative)

Under Alternative 2, 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 (Table 3.0-9). The activities would occur in the same locations and in a similar manner as were analyzed previously and above for Alternative 1.

Therefore, impacts on sea turtles under Alternative 2 from energy stressors, including in-water electromagnetic devices, would be negligible.

Pursuant to the ESA, the use of in-water electromagnetic devices during training and testing activities, as described under Alternative 2 would have no effect on ESA-listed sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.3.3 Impacts from In-Water Electromagnetic Devices 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. Energy stressors as listed above would not be introduced into the marine environment. 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 energy 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 lessen the potential for energy impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.3.4 Impacts from High-Energy Lasers Under Alternative 1

Alternative 1 would introduce high-energy lasers into the Study Area, which is analyzed in this SEIS/OEIS as a new substressor not previously analyzed in the 2015 MITT Final EIS/OEIS. As stated previously, the Navy conducted statistical modeling to estimate the number of potential exposures of sea turtles to high-energy laser beams. The statistical probability and methods calculation are included in Appendix J (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures from Military Expended Materials) in this SEIS/OEIS (see Table J-2). The modeling estimated the potential direct strike exposures to a sea turtle for a worst-case scenario. Model input values include high-energy laser use data (e.g., number of high-energy laser exercises and laser beam footprint), size of the training or testing area, sea turtle density data, and animal footprint. To estimate the probability of hitting a sea turtle in a worst-case scenario (based on assumptions listed below), the impact area for all laser training and testing events was summed over one year. Finally, the sea turtle with the highest average seasonal density within the training or testing area (green sea turtles) was used in the analysis. This approach ensures that all other species with a lower density would have a lower probability of being struck by the laser.

Under Alternative 1, the modeling estimated 0.000025 annual sea turtle exposures, an extremely low estimate (see Table J-2, in Appendix J, Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures from Military Expended Materials). Based on the very low number of annual exposures, the characteristics of activities that would use high-energy lasers (e.g., short range distance from source to target, high-precision targeting, short duration of the energized beam), and likely avoidance behavior of sea turtles to other stressors (e.g., vessel or aircraft noise), there is a reasonable assurance that there is no risk to sea turtles from high-energy laser use within the Study Area, and that the risk of exposure is discountable.

Pursuant to the ESA, the use of high-energy lasers during training and testing activities as described under Alternative 1 may affect ESA-listed sea turtles.

3.5.2.3.5 Impacts from High-Energy Lasers Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of proposed activities involving the use of high-energy lasers would increase from Alternative 1 (Table 3.0-10) and the 2015 MITT Final EIS/OEIS. The increase in the number of events that use high-energy lasers is reflected in the Navy's statistical modeling of potential exposures of sea turtles with a slight increase in the model's estimates. As shown in Table J-2 in Appendix J (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures from Military Expended Materials) high-energy laser use under Alternative 2 would result in 0.000027 exposures every year. As with Alternative 1, based on the very low number of annual exposures, the characteristics of activities that would use high-energy lasers (e.g., short range distance from source to target, high-precision targeting, short duration of the energized beam), and likely avoidance behavior of sea turtles to other stressors (e.g., vessel or aircraft noise), there is a reasonable assurance that there is no risk to sea turtles from high-energy laser use within the Study Area, and that the risk of exposure is discountable.

Pursuant to the ESA, the use of in-water electromagnetic devices and high-energy lasers during training and testing activities as described under Alternative 2 may affect ESA-listed sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.3.6 Impacts from High-Energy Lasers 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. Energy stressors as listed above would not be introduced into the marine environment. 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 energy 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 lessen the potential for energy impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.4 Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors are discussed in Section 3.0.4.4 (Physical Disturbance and Strike Stressors). Physical disturbance and strike stressors that may impact sea turtles include (1) vessels and in-water devices, (2) military expended materials, and (3) seafloor devices. The annual number of events including vessels and in-water devices, the annual number of military expended materials, and the annual number of events including seafloor devices are shown in Tables 3.0-12 through 3.0-17 and Table 3.0-19. The Navy will implement further mitigation measures to avoid or reduce potential impacts of towed in-water devices, non-explosive practice munitions, and vessel movements (see Sections 5.3.4.1 through 5.3.4.3).

There have been no known instances of physical disturbance or strike to any sea turtle in the Study Area as a result of Navy training and testing activities prior to or since the 2015 MITT Final EIS/OEIS.

3.5.2.4.1 Impacts from Physical Disturbance and Strike Stressors Under Alternative 1

Under Alternative 1, analysis of the individual substressors 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 sea turtles have decreased in comparison to the 2015 MITT Final EIS/OEIS (Tables 3.0-12 through 3.0-17 and Table 3.0-19). The number of small-caliber munitions would increase under Alternative 1. Small-caliber munitions are inert, are meant to be aimed at targets, and are not long-range weapons. As a result, sea turtles are extremely unlikely to be disturbed or struck by expended small-caliber munitions.

It is likely that green sea turtles within nearshore waters of western Guam and Apra Harbor would be at risk for vessel strike. During the section 7(a)(2) consultation between the Navy and NMFS, NMFS provided unpublished data to the Navy regarding green sea turtle strandings on Guam. For 2018, the only year provided by NMFS, there were three reported green sea turtle strandings attributable to vessel strikes (see Section 3.5.1.6.2.3, Species-Specific Threats). Whether these strandings were from Navy, commercial, or recreational vessels is not determinable; however, no vessel strikes for sea turtles were reported by the Navy during the reporting time period. Further, according to Apra Harbor vessel transit information included in the section 7(a)(2) consultation between the Navy and NMFS, there are more civilian vessel transits through Apra Harbor (86 percent) than Navy transits (14 percent). In areas outside the Study Area (e.g., Hawaii and Southern California), there have been recorded military vessel strikes of sea turtles. However, these are areas where the number of military vessels is much higher and training and testing activities occur more often than in the Study Area. Given the reduction in physical disturbance and strike stressors for this SEIS/OEIS, the findings presented in the 2015 MITT Final EIS/OEIS, Section 3.5.2.4 (Physical Disturbance and Strike Stressors) and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015) remain valid.

Pursuant to the ESA, the use of vessels and in-water devices, military expended materials, and seafloor devices as described under Alternative 1 may affect ESA-listed sea turtles.

3.5.2.4.2 Impacts from Physical Disturbance and Strike Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, physical disturbance and strike stressors during training and testing activities would decrease compared to the 2015 MITT Final EIS/OEIS (Tables 3.0-12 through 3.0-17 and Table 3.0-19), 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, the potential for strikes of sea turtles from in-water devices, military expended materials, and seafloor devices are unlikely to occur. As described above for Alternative 1, vessel strikes of sea turtles have been reported within Apra Harbor. These vessel strikes are not likely attributable to Navy activities because no vessel strikes were reported by the Navy, and the majority of vessel traffic is comprised of civilian vessels. Because vessel strike by military vessels cannot be wholly discounted, the Navy is consulting with NMFS on this stressor type and has included procedural mitigation to decrease the potential of vessel strike of sea turtles within Apra Harbor, other inshore areas, and training and testing areas at sea.

Pursuant to the ESA, the use of vessels and in-water devices, military expended materials, and seafloor devices as described under Alternative 2 may affect ESA-listed sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.4.3 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 this Proposed Action would continue to occur. Physical disturbance and strike stressors as listed above would not be introduced into the marine environment. 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 physical disturbance and strike 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 lessen the potential for physical disturbance and strike impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.5 Entanglement Stressors

Entanglement stressors are discussed in Section 3.0.4.5. Entanglement stressors considered for sea turtles include (1) fiber optic cables and guidance wires, and (2) decelerators/parachutes. The annual number of wires and cables and decelerators/parachutes proposed under the alternatives and in comparison to current ongoing activities are presented in Tables 3.0-22 through 3.0-24. There have been no known instances of any sea turtle being entangled in wires and cables, or decelerators/ parachutes associated with training and testing activities prior to or since the 2015 MITT Final EIS/OEIS.

3.5.2.5.1 Impacts from Entanglement Stressors Under Alternative 1

Under Alternative 1, the annual number of entanglement stressors would decrease compared to the 2015 MITT Final EIS/OEIS (Tables 3.0-22 through 3.0-24). Therefore, the analysis from the 2015 MITT Final EIS/OEIS remains valid. The analysis presented in the 2015 MITT Final EIS/OEIS (Section 3.5.2.5, Entanglement Stressors) and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015) determined that impacts on sea turtles from entanglement stressors are not anticipated.

Pursuant to the ESA, the use of fiber optic cable and guidance wires and decelerators/parachutes as described under Alternative 1 may affect ESA-listed sea turtles.

3.5.2.5.2 Impacts from Entanglement Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of entanglement stressors would decrease in comparison to current ongoing activities for fiber optic cable and decelerators/parachutes but would increase for the annual number of expended guidance wire (Tables 3.0-22 through 3.0-24). 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 3.5.2.5, Entanglement Stressors) and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015) remain valid. Impacts on sea turtles from entanglement stressors are not anticipated.

Pursuant to the ESA, the use of fiber optic cable and guidance wires and decelerators/parachutes as described above under Alternative 2 may affect ESA-listed sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.5.3 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 this Proposed Action would continue to occur. Entanglement stressors as listed above would not be introduced into the marine environment. 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 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 lessen the potential for entanglement of individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.6 Ingestion Stressors

Ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) are discussed in Section 3.0.4.6. Types of materials that could become ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) during training and testing in the Study Area include non-explosive practice munitions (small- and medium-caliber), fragments from explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and decelerators/parachutes. The annual number of events including military expended materials are shown in Tables 3.0-14 through 3.0-17 and Tables 3.0-25 through 3.0-26. As discussed in Section 3.5.4.6.3 (Impacts from Munitions) of the 2015 MITT Final EIS/OEIS, the number of munitions and explosive munitions fragments that an individual sea turtle could encounter would generally be low, based on the patchy distribution of both the munitions and the habitats where sea turtles forage. For the more numerous small-caliber munitions, these expended material-type items are inert, small in size, do not resemble prey items, and end up as part of the seafloor, where they are unlikely to be encountered by most sea turtles. In addition, it is assumed for sea turtle 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.

3.5.2.6.1 Impacts from Ingestion Stressors Under Alternative 1

Under Alternative 1, analysis of the individual substressors 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 sea turtles have decreased (Tables 3.0-14 through 3.0-17 and Tables 3.0-25 through 3.0-26). For the reasons noted above, the Navy has determined that potential impacts from ingestion stressors 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 harm of sea turtles or jeopardize the continued existence of any sea turtle species (National Oceanic and Atmospheric Administration, 2015). 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 sea turtles from ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) in the Study Area are not anticipated.

Pursuant to the ESA, the use of munitions and other military expended materials as described under Alternative 1 may affect ESA-listed sea turtles.

3.5.2.6.2 Impacts from Ingestion Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, of the number of military expended materials would decrease compared to the 2015 MITT Final EIS/OEIS, with the exception of increased use of small-caliber munitions (Tables 3.0-14 through 3.0-17 and Tables 3.0-25 through 3.0-26). 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 sea turtles from ingestion of military expended materials under Alternative 2 are not expected.

Pursuant to the ESA, the use of munitions and other military expended materials as described under Alternative 2 may affect ESA-listed sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.6.3 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 this Proposed Action would continue to occur. Ingestion stressors as listed above would not be introduced into the marine environment. 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 ingestion 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 lessen the potential for individual sea turtles to ingest items expended during training and testing activities, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.7 Secondary Stressors

As discussed in Section 3.5.3.6 (Secondary Stressors) of the 2015 MITT Final EIS/OEIS, secondary stressors from training and testing activities could pose indirect impacts on sea turtles via habitat degradation or an effect on prey availability. These stressors include (1) explosives, (2) explosive byproducts and unexploded ordnance, (3) metals, and (4) chemicals. Analyses of the potential impacts on sediments and water quality from the proposed training and testing activities are discussed in detail in Section 3.1 (Sediments and Water Quality) of the 2015 MITT Final EIS/OEIS. The analysis of explosives, explosive byproducts, metals, chemicals, and the transmission of diseases and parasites and their potential to indirectly impact sea turtles has not appreciably changed and is presented in detail in Section 3.5.4.7 (Secondary Stressors) of the 2015 MITT Final EIS/OEIS.

The analysis 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. Given that the concentration of unexploded ordnance, explosion byproducts, metals, and other chemicals would never exceed that of a World War II dump site where minimal concentrations were detected only within a few feet of the ordnance (Briggs et al., 2016; Edwards et al., 2016; Kelley et al., 2016; Smith & Marx, 2016), indirect impacts on sea turtles from the Proposed Action would be negligible and would have no long-term effect on habitat or prey.

3.5.3 Summary of Potential Impacts on Sea Turtles

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 3.5.2.1 (Acoustic Stressors) through Section 3.5.2.6 (Ingestion Stressors) and, for ESA-listed species, summarized in Section 3.5.4 (Endangered Species Act Determinations).

There are generally two ways that a sea turtle could be exposed to multiple stressors. The first would be if a sea turtle 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 sea turtle 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 sea turtle species, it is very unlikely that a sea turtle 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 sea turtle 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 sea turtle 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, sea turtles that experience temporary hearing loss or injury from acoustic stressors could be more susceptible to physical disturbance and strike stressors through a decreased ability to detect and avoid threats. Sea turtles that experience behavioral and physiological consequences of ingestion stressors could be more susceptible to entanglement and physical strike stressors via malnourishment and disorientation. These cumulative, synergistic, and antagonistic interactions between multiple stressors both natural and anthropogenic have just begun to be investigated and the exact mechanisms each stressor contributes to individual fitness is poorly understood. To date, the majority of scientific investigations on this topic have been on marine mammals rather than sea turtles (Murray et al., 2020; National Academies of Sciences Engineering and Medicine, 2017). Based on current best available science, the effects of multiple synergistic stressors over time cannot be realistically or precisely modeled for sea turtles. The Navy's quantitative and qualitative analyses are consistently conservative and likely over-predict impacts on sea turtles.

Research and monitoring efforts have included before-, during-, and after-event observations and surveys; data collection through long-term studies in areas where the Navy conducts activities; 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 the types of impacts that animals may be experiencing in these areas. To date, the findings from the research and monitoring efforts and the regulatory conclusions from previous analyses by NMFS, including the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Marine Fisheries Service, 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 sea turtles.

3.5.4 Endangered Species Act Determination

Pursuant to the ESA, Navy training and testing activities presented in this SEIS/OEIS may affect ESA-listed sea turtles. There is no designated critical habitat for any sea turtle species in the MITT Study Area. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA, with training and testing activities described under Alternative 2 in this SEIS/OEIS as the action description in the consultation process. The outcome of those consultations pursuant to the ESA are described in this MITT Final SEIS/OEIS.

3.5.5 Public Comments

The public raised a number of issues during the scoping period in regard to Sea Turtles. The issues are summarized in the list below. Comments received from the public during the Draft SEIS/OEIS commenting period related to sea turtles are addressed in Appendix K (Public Comment Responses).

- **Lack of sea turtle information in waters surrounding FDM –** One commenter noted a lack of studies documenting the condition of sea turtles in waters surrounding FDM. Multi-year dive studies conducted by Smith and Marx (2016) have reported roughly comparable numbers of sea turtles (only green sea turtles and hawksbill sea turtles have been observed in waters surrounding FDM) during every survey between 1999 and 2012. None of the specimens seen by the authors had any visible fibropapilloma tumors, barnacles, lesions, or other visible abnormalities. The number of sea turtle sightings during each dive session was low, ranging from 0.13 to 0.36 per biologist per dive in each year. For comparative purposes, some study sites off Oahu, Hawaii which have been surveyed since 1999 by the authors have averaged more than 10 sea turtles sighted per dive during all seasons. This equates to 28 times higher than the FDM densities. The precipitous sea cliffs, lack of suitable haulout sites or beaches preclude nesting or basking at FDM. In addition, Smith and Marx (2016) noted that no sea turtle remains, such as carapace or bone fragments, have ever been sighted or reported at FDM (the authors have encountered such remains at various locations in the Bahamas, Cayman Islands, Hawaiian Islands and Malaysia, which support resident sea turtle populations). In summary, sea turtles around FDM probably represent transient individuals and not a resident population. Although waters surrounding FDM likely maintain healthy foraging grounds for transient turtles, they do not congregate in high concentrations in these waters.

- **Habitat, prey availability, and overall health of sea turtles –** The Navy received comments expressing concerns over impacts on the general marine environment from military training and testing activities. The Navy has included a detailed summary of recent published studies that describe multi-year dive studies conducted by Smith and Marx (2016), which provide an indication of habitat quality in waters surrounding a location of concentrated and intensive military activities. The results of these surveys are included in Section 3.1.1.1.4 (Farallon de Medinilla) of this SEIS/OEIS. Throughout all dive surveys, the coral fauna at FDM were observed to be healthy and robust, which suggests healthy foraging habitats for sea turtles. The nearshore physical environment and basic habitat types at FDM have remained unchanged over the 13 years of survey activity. These conclusions are based on (1) a limited amount of physical damage, (2) very low levels of partial mortality and disease (less than 1 percent of all species observed), (3) absence of excessive mucus production, (4) good coral recruitment, (5) complete recovery by 2012 of the 2007 bleaching event, and (6) a limited number of macrobioeroders and an absence of invasive crown of thorns starfish (*Acanthaster planci*). These factors suggest that potential impacts from training and testing activities are not sufficient as to adversely impact water quality, substantiated by repeated dive surveys discussed above (Smith & Marx, 2016), and thereby reduce habitat quality for sea turtle populations.

REFERENCES

Avens, L. (2003). Use of multiple orientation cues by juvenile loggerhead sea turtles *Caretta caretta*. *The Journal of Experimental Biology, 206*(23), 4317–4325.

Balazs, G. H. (1986). Fibropapillomas in Hawaiian green turtles. *Marine Turtle Newsletter, 39*, 1–3.

Bartol, S. M., J. A. Musick, and M. L. Lenhardt. (1999). Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). *Copeia, 1999*(3), 836–840.

Bartol, S. M., and D. R. Ketten. (2006). *Turtle and Tuna Hearing* (NOAA Technical Memorandum NMFS-PIFSC-7). Honolulu, HI: Pacific Islands Fisheries Science Center.

Becking, L. E., T. C. J. M. van Bussel, A. O. Debrot, and M. J. A. Christianen. (2014). First record of a Caribbean green turtle (*Chelonia mydas*) grazing on invasive seagrass (*Halophila stipulacea*). *Caribbean Journal of Science, 48*(2–3), 162–163.

Berkson, H. (1967). Physiological adjustments to deep diving in the Pacific green turtle (*Chelonia mydas agassizii*). *Comparative Biochemistry and Physiology, 21*(3), 507–524.

Birney, K., M. Byrd, S. Hastings, S. Herron, B. Shafritz, and R. Freedman. (2015). *Report on the 2014 Vessel Speed Reduction Incentive Trial in the Santa Barbara Channel* (Protecting Blue Whales and Blue Skies). Santa Barbara, CA: National Marine Sanctuaries Channel Islands, Santa Barbara County Air Pollution Control District, Environmental Defense Center, and the National Marine Sanctuary Foundation.

Bjorndal, K. A., A. B. Bolten, and C. Lagueux. (1994). Ingestion of Marine Debris by Juvenile Sea Turtles in Coastal Florida Habitats. *Marine Pollution Bulletin, 28*(3), 154–158.

Bjorndal, K. A. (1997). Foraging ecology and nutrition of sea turtles. In P. L. Lutz & J. A. Musick (Eds.), *The Biology of Sea Turtles* (pp. 199–231). Boca Raton, FL: CRC Press.

Bolten, A. B. (2003). Active swimmers-passive drifters: The oceanic juvenile stage of loggerheads in the Atlantic system. In A. B. Bolten & B. E. Witherington (Eds.), *Loggerhead Sea Turtles* (pp. 63–78). Washington, DC: Smithsonian Books.

Bowen, B. W., A. L. Bass, S.-M. Chow, M. Bostrom, K. A. Bjorndal, A. B. Bolten, T. Okuyama, B. M. Bolker, S. Epperly, E. Lacasella, D. Shaver, M. Dodd, S. R. Hopkins-Murphy, J. A. Musick, M. Swingle, K. Rankin-Baransky, W. Teas, W. N. Witzell, and P. H. Dutton. (2004). Natal homing in juvenile loggerhead turtles *(Caretta caretta)*. *Molecular Ecology, 13*, 3797–3808.

Briggs, C., S. M. Shjegstad, J. A. K. Silva, and M. H. Edwards. (2016). Distribution of chemical warfare agent, energetics, and metals in sediments at a deep-water discarded military munitions site. *Deep Sea Research Part II: Topical Studies in Oceanography, 128*, 63–69.

Brothers, J. R., and K. J. Lohmann. (2015). Evidence for geomagnetic imprinting and magnetic navigation in the natal homing of sea turtles. *Current Biology, 25*(3), 392–396.

Christian, E. A., and J. B. Gaspin. (1974). *Swimmer Safe Standoffs from Underwater Explosions. Navy Science Assistance Program Project No. PHP-11-73*. White Oak, MD: Naval Ordnance Laboratory.

Clark, C. W., M. W. Brown, and P. Corkeron. (2010). Visual and acoustic surveys for North Atlantic right whales, *Eubalaena glacialis*, in Cape Cod Bay, Massachusetts, 2001–2005: Management implications. *Marine Mammal Science, 26*(4), 837–843.

Clark, H. R., and C. J. Gobler. (2016). Diurnal fluctuations in CO_2 and dissolved oxygen concentrations do not provide a refuge from hypoxia and acidification for early-life-stage bivalves. *Marine Ecology Progress Series, 558*, 1–14.

Clark, S. L., and J. W. Ward. (1943). The effects of rapid compression waves on animals submerged in water. *Surgery, Gynecology & Obstetrics, 77*, 403–412.

Conant, T. A., P. H. Dutton, T. Eguchi, S. P. Epperly, C. C. Fahy, M. H. Godfrey, S. L. MacPherson, E. E. Possardt, B. A. Schroeder, J. A. Seminoff, M. L. Snover, C. M. Upite, and B. E. Witherington. (2009). *Loggerhead sea turtle (Caretta caretta) 2009 status review under the U.S. Endangered Species Act* (Report of the loggerhead biological review team to the National Marine Fisheries Service, August 2009). Silver Spring, MD: Loggerhead Biological Review Team.

Cook, S. L., and T. G. Forrest. (2005). Sounds produced by nesting leatherback sea turtles (*Dermochelys coriacea*). *Herpetological Review, 36*(4), 387–389.

DeRuiter, S. L., and K. L. Doukara. (2012). Loggerhead turtles dive in response to airgun sound exposure. *Endangered Species Research, 16*(1), 55–63.

Dew, L. A., R. G. Owen, and M. J. Mulroy. (1993). Changes in size and shape of auditory hair cells in vivo during noise-induced temporary threshold shift. *Hearing Research, 66*(1), 99–107.

Dow Piniak, W. E., S. A. Eckert, C. A. Harms, and E. M. Stringer. (2012). *Underwater Hearing Sensitivity of the Leatherback Sea Turtle (Dermochelys coriacea): Assessing the Potential Effect of Anthropogenic Noise* (OCS Study BOEM 2012-01156). Herndon, VA: U.S. Department of the Interior, Bureau of Ocean Energy Management.

Edwards, M. H., S. M. Shjegstad, R. Wilkens, J. C. King, G. Carton, D. Bala, B. Bingham, M. C. Bissonnette, C. Briggs, N. S. Bruso, R. Camilli, M. Cremer, R. B. Davis, E. H. DeCarlo, C. DuVal, D. J. Fornari, I. Kaneakua-Pia, C. D. Kelley, S. Koide, C. L. Mah, T. Kerby, G. J. Kurras, M. R. Rognstad, L. Sheild, J. Silva, B. Wellington, and M. V. Woerkom. (2016). The Hawaii undersea military munitions assessment. *Deep Sea Research Part II: Topical Studies in Oceanography, 128*, 4–13.

Eldredge, L. G. (2003). The marine reptiles and mammals of Guam. *Micronesica, 35-36*, 653–660.

Endres, C. S., N. F. Putman, D. A. Ernst, J. A. Kurth, C. M. F. Lohmann, and K. J. Lohmann. (2016). Multi-modal homing in sea turtles: Modeling dual use of geomagnetic and chemical cues in island-finding. *Frontiers in Behavioral Neuroscience, 10*, 19.

Falcone, E. A., G. S. Schorr, S. L. Watwood, S. L. DeRuiter, A. N. Zerbini, R. D. Andrews, R. P. Morrissey, and D. J. Moretti. (2017). Diving behaviour of Cuvier's beaked whales exposed to two types of military sonar. *Royal Society Open Science, 4*(170629), 1–21.

Ferrara, C. R., R. C. Vogt, M. R. Harfush, R. S. Sousa-Lima, E. Albavera, and A. Tavera. (2014). First evidence of leatherback turtle (*Dermochelys coriacea*) embryos and hatchlings emitting sounds. *Chelonian Conservation and Biology, 13*(1), 110–114.

Flower, J. E., T. M. Norton, K. M. Andrews, S. E. Nelson, Jr., C. E. Parker, L. M. Romero, and M. A. Mitchell. (2015). Baseline plasma corticosterone, haematological and biochemical results in nesting and rehabilitating loggerhead sea turtles (*Caretta caretta*). *Conservation Physiology, 3*(1), cov003.

Fossette, S., S. Ferraroli, H. Tanaka, Y. Ropert-Coudert, N. Arai, K. Sato, Y. Naito, Y. Le Maho, and J. Georges. (2007). Dispersal and dive patterns in gravid leatherback turtles during the nesting season in French Guiana. *Marine Ecology Progress Series, 338*, 233–247.

Fuentes, M. M. P. B., D. A. Pike, A. Dimatteo, and B. P. Wallace. (2013). Resilience of marine turtle regional management units to climate change. *Global Change Biology, 19*(5), 1399–1406.

Fukuoka, T., M. Yamane, C. Kinoshita, T. Narazaki, G. J. Marshall, K. J. Abernathy, N. Miyazaki, and K. Sato. (2016). The feeding habit of sea turtles influences their reaction to artificial marine debris. *Scientific Reports, 6*, 28015.

Garcia-Parraga, D., J. L. Crespo-Picazo, Y. B. de Quiros, V. Cervera, L. Marti-Bonmati, J. Diaz-Delgado, M. Arbelo, M. J. Moore, P. D. Jepson, and A. Fernandez. (2014). Decompression sickness ('the bends') in sea turtles. *Diseases of Aquatic Organisms, 111*(3), 191–205.

Gill, A. B., I. Gloyne-Philips, J. Kimber, and P. Sigray. (2014). Marine Renewable Energy, Electromagnetic (EM) Fields and EM-Sensitive Animals. In M. Shields & A. Payne (Eds.), *Marine Renewable Energy Technology and Environmental Interactions. Humanity and the Sea* (pp. 61–79). Dordrecht, Netherlands: Springer.

Gitschlag, G. R. (1996). Migration and diving behavior of Kemp's ridley (Garman) sea turtles along the U.S. southeastern Atlantic coast. *Journal of Experimental Marine Biology and Ecology, 205*, 115–135.

Goertner, J. F. (1978). *Dynamical Model for Explosion Injury to Fish*. Dalgren, VA: U.S. Department of the Navy, Naval Surface Weapons Center.

Goertner, J. F. (1982). *Prediction of Underwater Explosion Safe Ranges for Sea Mammals*. Dahlgren, VA: Naval Surface Weapons Center.

Greaves, F. C., R. H. Draeger, O. A. Brines, J. S. Shaver, and E. L. Corey. (1943). An experimental study of concussion. *United States Naval Medical Bulletin, 41*(1), 339–352.

Gregory, L. F., and J. R. Schmid. (2001). Stress response and sexing of wild Kemp's ridley sea turtles (*Lepidochelys kempii*) in the Northeastern Gulf of Mexico. *General and Comparative Endocrinology, 124*, 66–74.

Hawkes, L. A., A. C. Broderick, M. S. Coyne, M. H. Godfrey, L.-F. Lopez-Jurado, P. Lopez-Suarez, S. E. Merino, N. Varo-Cruz, and B. J. Godley. (2006). Phenotypically linked dichotomy in sea turtle foraging requires multiple conservation approaches. *Current Biology, 16*, 990–995.

Hays, G. C., J. D. R. Houghton, C. Isaacs, R. S. King, C. Lloyd, and P. Lovell. (2004). First records of oceanic dive profiles for leatherback turtles, *Dermochelys coriacea*, indicate behavioural plasticity associated with long-distance migration. *Animal Behaviour, 67*, 733–743.

Henry, W. R., and M. J. Mulroy. (1995). Afferent synaptic changes in auditory hair cells during noise-induced temporary threshold shift. *Hearing Research, 84*(1), 81–90.

Hetherington, T. (2008). Comparative anatomy and function of hearing in aquatic amphibians, reptiles, and birds. In J. G. M. Thewissen & S. Nummela (Eds.), *Sensory Evolution on the Threshold* (pp. 182–209). Berkeley, CA: University of California Press.

Hochscheid, S., C. R. McMahon, C. J. A. Bradshaw, F. Maffucci, F. Bentivegna, and G. C. Hays. (2007). Allometric scaling of lung volume and its consequences for marine turtle diving performance. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology, 148*(2), 360–367.

Hochscheid, S. (2014). Why we mind sea turtles' underwater business: A review on the study of diving behavior. *Journal of Experimental Marine Biology and Ecology, 450*, 118–136.

Hoopes, L. A., A. M. Landry Jr., and E. K. Stabenau. (2000). Physiological effects of capturing Kemp's ridley sea turtles, *Lepidochelys kempii*, in entanglement nets. *Canadian Journal of Zoology, 78*(11), 1941–1947.

Houghton, J. D. R., M. J. Callow, and G. C. Hays. (2003). Habitat utilization by juvenile hawksbill turtles (*Eretmochelys imbricata*, Linnaeus, 1766) around a shallow water coral reef. *Journal of Natural History, 37*, 1269–1280.

Hubbs, C., and A. Rechnitzer. (1952). Report on experiments designed to determine effects of underwater explosions on fish life. *California Fish and Game, 38*, 333–366.

James, M. C., S. A. Eckert, and R. A. Myers. (2005). Migratory and reproductive movements of male leatherback turtles (*Dermochelys coriacea)*. *Marine Biology, 147*, 845–853.

Kelley, C., G. Carton, M. Tomlinson, and A. Gleason. (2016). Analysis of towed camera images to determine the effects of disposed mustard-filled bombs on the deep water benthic community off south Oahu. *Deep Sea Research Part II: Topical Studies in Oceanography, 128*, 34–42.

Ketten, D. R., and S. Moein-Bartol. (2006). *Functional Measures of Sea Turtle Hearing*. Woods Hole, MA: Woods Hole Oceanographic Institution.

Klima, E. F., G. R. Gitschlag, and M. L. Renaud. (1988). Impacts of the explosive removal of offshore petroleum platforms on sea turtles and dolphins. *Marine Fisheries Review, 50*(3), 33–42.

Kolinski, S. P., R. K. Hoeke, S. R. Holzwarth, L. I. Ilo, E. F. Cox, R. C. O'Conner, and P. S. Vroom. (2006). Nearshore distribution and an abundance estimate for green sea turtles, *Chelonia mydas*, at Rota Island, Commonwealth of the Northern Mariana Islands. *Pacific Science, 60*(4), 509–522.

Kremers, D., J. Lopez Marulanda, M. Hausberger, and A. Lemasson. (2014). Behavioural evidence of magnetoreception in dolphins: Detection of experimental magnetic fields. *Die Naturwissenschaften, 101*(11), 907–911.

Kremers, D., A. Celerier, B. Schaal, S. Campagna, M. Trabalon, M. Boye, M. Hausberger, and A. Lemasson. (2016). Sensory Perception in Cetaceans: Part II—Promising Experimental Approaches to Study Chemoreception in Dolphins. *Frontiers in Ecology and Evolution, 4*(50), 1–9.

Laloë, J.-O., N. Esteban, J. Berkel, and G. C. Hays. (2016). Sand temperatures for nesting sea turtles in the Caribbean: Implications for hatchling sex ratios in the face of climate change. *Journal of Experimental Marine Biology and Ecology, 474*, 92–99.

Lavender, A. L., S. M. Bartol, and I. K. Bartol. (2014). Ontogenetic investigation of underwater hearing capabilities in loggerhead sea turtles (*Caretta caretta*) using a dual testing approach. *The Journal of Experimental Biology, 217*(Pt 14), 2580–2589.

Lenhardt, M. L., S. Bellmund, R. A. Byles, S. W. Harkins, and J. A. Musick. (1983). Marine turtle reception of bone-conducted sound. *The Journal of Auditory Research, 23*, 119–125.

Lenhardt, M. L., R. C. Klinger, and J. A. Musick. (1985). Marine turtle middle-ear anatomy. *The Journal of Auditory Research, 25*, 66–72.

Lenhardt, M. L. (1994). *Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (Caretta caretta).* Paper presented at the Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. Hilton Head, SC.

Lutcavage, M. E., P. G. Bushnell, and D. R. Jones. (1992). Oxygen stores and aerobic metabolism in the leatherback sea turtle. *Canadian Journal of Zoology, 70*(2), 348–351.

Lutcavage, M. E., and P. L. Lutz. (1997). Diving Physiology. In P. L. Lutz & J. A. Musick (Eds.), *The Biology of Sea Turtles* (pp. 277–296). Boca Raton, FL: CRC Press.

Martin, K. J., S. C. Alessi, J. C. Gaspard, A. D. Tucker, G. B. Bauer, and D. A. Mann. (2012). Underwater hearing in the loggerhead turtle (*Caretta caretta*): A comparison of behavioral and auditory evoked potential audiograms. *The Journal of Experimental Biology, 215*(17), 3001–3009.

Martin, S. L., K. S. Van Houtan, T. T. Jones, C. F. Aguon, J. T. Gutierrez, R. B. Tibbatts, S. B. Wusstig, and J. D. Bass. (2016). Five decades of marine megafauna surveys from Micronesia. *Frontiers in Marine Science, 2*(116), 1–13.

McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch, and K. A. McCabe. (2000). *Marine Seismic Surveys: Analysis and Propagation of Air-gun Signals; and Effects of Air-gun Exposure on Humpback Whales, Sea Turtles, Fishes and Squid*. Bentley, Australia: Centre for Marine Science and Technology.

Moein Bartol, S. E., J. A. Musick, J. A. Keinath, D. E. Barnard, M. L. Lenhardt, and R. George. (1995). Evaluation of Seismic Sources for Repelling Sea Turtles from Hopper Dredges. In L. Z. Hales (Ed.), *Sea Turtle Research Program: Summary Report* (Vol. Technical Report CERC-95, pp. 90–93). Kings Bay, GA: U.S. Army Engineer Division, South Atlantic, Atlanta, GA and U.S. Naval Submarine Base.

Mrosovsky, N. (1972). Spectrographs of the sounds of leatherback turtles. *Herpetologica, 28*(3), 256–258.

Mrosovsky, N., G. D. Ryan, and M. C. James. (2009). Leatherback turtles: The menace of plastic. *Marine Pollution Bulletin, 58*(2), 287–289.

Murray, C., L. Hannah, and A. Locke. (2020). *A Review of Cumulative Effects Research and Assessment in Fisheries and Oceans Canada*. Sidney, Canada: Canadian Technical Report of Fisheries and Aquatic Sciences.

Murray, C. C., A. Bychkov, T. Therriault, H. Maki, and N. Wallace. (2015). The impact of Japanese tsunami debris on North America. *PICES Press, 23*(1), 28.

Narazaki, T., K. Sato, K. J. Abernathy, G. J. Marshall, and N. Miyazaki. (2013). Loggerhead turtles (*Caretta caretta*) use vision to forage on gelatinous prey in mid-water. *PLoS ONE, 8*(6), e66043.

National Academies of Sciences Engineering and Medicine. (2017). *Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals*. Washington, DC: The National Academies Press.

National Marine Fisheries Service, and U.S. Fish and Wildlife Service. (1991). *Recovery Plan for U.S. Populations of Atlantic Green Turtle (Chelonia mydas)*. Washington, DC: National Marine Fisheries Service.

National Marine Fisheries Service, and U.S. Fish and Wildlife Service. (2008). *Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (Caretta caretta), Second Revision*. Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service. (2013). *2013 Annual Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Waters of the Western North Atlantic Ocean*. Woods Hole, MA and Miami, FL: Northeast Fisheries Science Center and Southeast Fisheries Science Center.

National Marine Fisheries Service, and U.S. Fish and Wildlife Service. (2014). *Olive Ridley Sea Turtle (Lepidochelys olivacea) 5-Year Review: Summary and Evaluation*. Silver Spring, MD: National Marine Fisheries Service Office of Protected Resources and U.S. Fish and Wildlife Service Southeast Region.

National Marine Fisheries Service. (2015a). *National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion and Conference Report; Biological Opinion and Conference Report on Mariana Islands Training and Testing and Issuance of an MMPA Rule and LOA*. Silver Spring, MD: Endangered Species Act Interagency Cooperation Division of the Office of Protected Resources, National Marine Fisheries Service.

National Marine Fisheries Service. (2015b). *Endangered Species Act Section 7 Biological Opinion and Conference Report U.S. Navy's Surveillance Towed Array Sensor System Low Frequency Active Sonar Routine Training, Testing, and Military Operations and NOAA's National Marine Fisheries Service, Office of Protected Resources' issuance of four letters of authorization for the U.S. Navy to "take" marine mammals incidental to Surveillance Towed Array Sensor System Low Frequency Active Sonar Routine Training, Testing, and Military Operations in areas of the Pacific Ocean for the period of August 15, 2015 through August 14, 2016 pursuant to the fiveyear MMPA regulation*. (FPR-2015-9119). Washington, DC: U.S. Department of the Navy.

National Oceanic and Atmospheric Administration. (2015). Takes of marine mammals incidental to specified activities; U.S. Navy training and testing activities in the Mariana Islands Training and Testing Study Area. *Federal Register, 80*(148), 46112–46171.

O'Hara, J., and J. R. Wilcox. (1990). Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. *Copeia, 1990*(2), 564–567.

O'Keeffe, D. J., and G. A. Young. (1984). *Handbook on the Environmental Effects of Underwater Explosions*. Silver Spring, MD: U.S. Navy, Naval Surface Weapons Center (Code R14).

Office of the Surgeon General. (1991). Conventional warfare ballistic, blast, and burn injuries. In R. Zajitchuk, Col. (Ed.), *U.S.A. Textbook of Military Medicine*. Washington, DC: Office of the Surgeon General.

Patino-Martinez, J., A. Marco, L. Quinones, and B. Godley. (2008). Globally significant nesting of the leatherback turtle (*Dermochelys coriacea*) on the Caribbean coast of Colombia and Panama. *Biological Conservation, 141*(8), 1982–1988.

Patrício, A. R., C. E. Diez, R. P. Van Dam, and B. J. Godley. (2016). Novel insights into the dynamics of green turtle fibropapillomatosis. *Marine Ecology Progress Series, 547*, 247–255.

Pepper, C. B., M. A. Nascarella, and R. J. Kendall. (2003). A review of the effects of aircraft noise on wildlife and humans, current control mechanisms, and the need for further study. *Environmental Management, 32*(4), 418–432.

Pike, D. A. (2014). Forecasting the viability of sea turtle eggs in a warming world. *Global Change Biology, 20*(1), 7–15.

Pike, D. A., E. A. Roznik, and I. Bell. (2015). Nest inundation from sea-level rise threatens sea turtle population viability. *Royal Society Open Science, 2*(7), 150127.

Piniak, W. E. D., D. A. Mann, C. A. Harms, T. T. Jones, and S. A. Eckert. (2016). Hearing in the juvenile green sea turtle (*Chelonia mydas*): A comparison of underwater and aerial hearing using auditory evoked potentials. *PLoS ONE, 11*(10), e0159711.

Popper, A. N., A. D. Hawkins, R. R. Fay, D. A. Mann, S. M. Bartol, T. J. Carlson, S. Coombs, W. T. Ellison, R. L. Gentry, M. B. Halvorsen, S. Løkkeborg, P. H. Rogers, B. L. Southall, D. G. Zeddies, and W. N. Tavolga. (2014). *ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI*. New York, NY and London, United Kingdom: Acoustical Society of America Press and Springer Briefs in Oceanography.

Putman, N. F., P. Verley, C. S. Endres, and K. J. Lohmann. (2015). Magnetic navigation behavior and the oceanic ecology of young loggerhead sea turtles. *The Journal of Experimental Biology, 218*(7), 1044–1050.

Reneker, J. L., and S. J. Kamel. (2016). Climate change increases the production of female hatchlings at a northern sea turtle rookery. *Ecology, 97*(12), 3257–3264.

Rice, M. R., and G. H. Balazs. (2008). Diving behavior of the Hawaiian green turtle (*Chelonia mydas*) during oceanic migrations. *Journal of Experimental Marine Biology and Ecology, 356*(1–2), 121–127.

Richmond, D. R., J. T. Yelverton, and E. R. Fletcher. (1973). *Far-Field Underwater-Blast Injuries Produced by Small Charges*. Washington, DC: Lovelace Foundation for Medical Education and Research, Defense Nuclear Agency.

Ridgway, S. H., E. G. Wever, J. G. McCormick, J. Palin, and J. H. Anderson. (1969). Hearing in the giant sea turtle, *Chelonia mydas*. *Proceedings of the National Academy of Sciences U.S.A., 64*(3), 884–890.

Rieth, T. M., T. L. Hunt, C. Lipo, and J. M. Wilmshurst. (2011). The 13th century Polynesian colonization of Hawaii Island. *Journal of Archaeological Science, 28*, 2740–2749.

Russell, D. J., and G. H. Balazs. (2015). Increased use of non-native algae species in the diet of the green turtle (*Chelonia mydas*) in a primary pasture ecosystem in Hawaii. *Aquatic Ecosystem Health & Management, 18*(3), 342–346.

Sakamoto, W., K. Sato, H. Tanaka, and Y. Naito. (1993). Diving patterns and swimming environment of two loggerhead turtles during internesting. *Nippon Suisan Gakkaishi, 59*(7), 1129–1137.

Salmon, M., T. T. Jones, and K. W. Horch. (2004). Ontogeny of diving and feeding behavior in juvenile seaturtles: Leatherback seaturtles (*Dermochelys coriacea* L) and green seaturtles (*Chelonia mydas* L) in the Florida current. *Journal of Herpetology, 38*(1), 36–43.

Schroeder, B. A., A. M. Foley, and D. A. Bagley. (2003). Nesting patterns, reproductive migrations, and adult foraging areas of loggerhead turtles. In A. B. Bolten & B. E. Witherington (Eds.), *Loggerhead Sea Turtles* (pp. 114–124). Washington, DC: Smithsonian Institution Press.

Schuyler, Q., B. D. Hardesty, C. Wilcox, and K. Townsend. (2014). Global analysis of anthropogenic debris ingestion by sea turtles. *Conservation Biology, 28*(1), 129–139.

Seminoff, J. A., C. D. Allen, G. H. Balazs, P. H. Dutton, T. Eguchi, H. L. Haas, S. A. Hargrove, M. P. Jensen, D. L. Klemm, A. M. Lauritsen, S. L. MacPherson, P. Opay, E. E. Possardt, S. L. Pultz, E. E. Seney, K. S. Van Houtan, and R. S. Waples. (2015). *Status Review of the Green Turtle (Chelonia mydas) Under the U.S. Endangered Species Act*. (NOAA Technical Memorandum NMFS-SWFSC-592). La Jolla, CA: Southwest Fisheries Science Center.

Shankar, K., J. Ramadevi, B. C. Choudhary, L. Singh, and R. K. Aggarwal. (2004). Phylogeography of olive ridley turtles (*Lepidochelys olivacea*) on the east coast of India: Implications for conservation theory. *Molecular Ecology, 13*, 1899–1909.

Smith, S. H., and D. E. Marx, Jr. (2016). De-facto marine protection from a Navy bombing range: Farallon de Medinilla, Mariana Archipelago, 1997 to 2012. *Marine Pollution Bulletin, 102*(1), 187–198.

Snoddy, J. E., M. Landon, G. Blanvillain, and A. Southwood. (2009). Blood biochemistry of sea turtles captured in gillnets in the lower Cape Fear River, North Carolina, USA. *Journal of Wildlife Management, 73*(8), 1394–1401.

Southall, B., A. Bowles, W. Ellison, J. Finneran, R. Gentry, C. Greene, D. Kastak, D. Ketten, J. Miller, P. Nachtigall, W. Richardson, J. Thomas, and P. Tyack. (2007). Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals, 33*(4), 122.

Southwood, A. L., R. D. Andrews, M. E. Lutcavage, F. V. Paladino, N. H. West, R. H. George, and D. R. Jones. (1999). Heart rates and diving behavior of leatherback sea turtles in the eastern Pacific Ocean. *The Journal of Experimental Biology, 202*, 1115–1125.

Stabenau, E. K., T. A. Heming, and J. F. Mitchell. (1991). Respiratory, acid-base and ionic status of Kemp's ridley sea turtles (*Lepidochelys kempii*) subjected to trawling. *Comparative Biochemistry and Physiology Part A: Physiology, 99*(1), 107–111.

Summers, T. M., T. T. Jones, S. L. Martin, J. R. Hapdei, J. K. Ruak, and C. A. Lepczyk. (2017). Demography of marine turtles in the nearshore environments of the Northern Mariana Islands. *Pacific Science, 71*(3), 269–286.

Swisdak, M. M., Jr., and P. E. Montanaro. (1992). *Airblast and Fragmentation Hazards from Underwater Explosions*. Silver Spring, MD: Naval Surface Warfare Center.

Teuten, E. L., S. J. Rowland, T. S. Galloway, and R. C. Thompson. (2007). Potential for plastics to transport hydrophobic contaminants. *Environmental Science and Technology, 41*(22), 7759–7764.

U.S. Department of the Navy. (2015a). *Final Mariana Islands Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement*. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific.

U.S. Department of the Navy. (2015b). *Regional Biosecurity Plan for Micronesia and Hawaii, Volume IV*. Mangilao, GU: University of Guam and the Secretariat of the Pacific Community.

U.S. Department of the Navy. (2015c). *Regional Biosecurity Plan for Micronesia and Hawaii, Volume III*. Mangilao, GU: University of Guam and the Secretariat of the Pacific Community.

U.S. Department of the Navy. (2015d). *Regional Biosecurity Plan for Micronesia and Hawaii, Volume I*. Mangilao, GU: University of Guam and the Secretariat of the Pacific Community.

U.S. Department of the Navy. (2017a). *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)*. San Diego, CA: Space and Naval Warfare Systems Command, Pacific.

U.S. Department of the Navy. (2017b). *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Technical Report prepared by Space and Naval Warfare Systems Center Pacific). San Diego, CA: Naval Undersea Warfare Center.

U.S. Department of the Navy. (2018). *2017 Living Marine Resources (LMR) Program Annual Report*. Port Hueneme, CA: Naval Facilities Engineering.

United Nations Environmental Program. (2005). *Marine Litter: An analytical overview*. Nairobi, Kenya: United Nations Environment Programme's Regional Seas Programme.

Valverde, R. A., D. W. Owens, D. S. MacKenzie, and M. S. Amoss. (1999). Basal and stress-induced corticosterone levels in olive ridley sea turtles (*Lepidochelys olivacea*) in relation to their mass nesting behavior. *Journal of Experimental Zoology, 284*(6), 652–662.

Viada, S. T., R. M. Hammer, R. Racca, D. Hannay, M. J. Thompson, B. J. Balcom, and N. W. Phillips. (2008). Review of potential impacts to sea turtles from underwater explosive removal of offshore structures. *Environmental Impact Assessment Review, 28*, 267–285.

Watwood, S. L., J. D. Iafrate, E. A. Reyier, and W. E. Redfoot. (2016). Behavioral Response of Reef Fish and Green Sea Turtles to Mid-Frequency Sonar. In A. N. Popper & A. Hawkins (Eds.), *The Effects of Noise on Aquatic Life II* (pp. 1213–1221). New York, NY: Springer.

Weir, C. R. (2007). Observations of marine turtles in relation to seismic airgun sound off Angola. *Marine Turtle Newsletter, 116*, 17–20.

Wiley, M. L., J. B. Gaspin, and J. F. Goertner. (1981). Effects of underwater explosions on fish with a dynamical model to predict fishkill. *Ocean Science and Engineering, 6*(2), 223–284.

Williams, S. L. (1988). *Thalassia testudinum* productivity and grazing by green turtles in a highly disturbed seagrass bed. *Marine Biology, 98*, 447–455.

Willis, K. L., J. Christensen-Dalsgaard, D. R. Ketten, and C. E. Carr. (2013). Middle ear cavity morphology is consistent with an aquatic origin for testudines. *PLoS ONE, 8*(1), e54086.

Witt, M. J., L. A. Hawkes, M. H. Godfrey, B. J. Godley, and A. C. Broderick. (2010). Predicting the impacts of climate change on a globally distributed species: The case of the loggerhead turtle. *The Journal of Experimental Biology, 213*(6), 901–911.

Work, T. M., and G. H. Balazs. (2013). Tumors in sea turtles: The insidious menace of fibropapillomatosis. *The Wildlife Professional, Fall 2013*, 44–47.

Yelverton, J. T., D. R. Richmond, E. R. Fletcher, and R. K. Jones. (1973). *Safe Distances From Underwater Explosions for Mammals and Birds*. Albuquerque, NM: Lovelace Foundation for Medical Education and Research.

Yelverton, J. T., and D. R. Richmond. (1981). *Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals.* Paper presented at the 102nd Meeting of the Acoustical Society of America. Miami Beach, FL.

Yudhana, A., J. Din, Sundari, S. Abdullah, and R. B. R. Hassan. (2010). Green turtle hearing identification based on frequency spectral analysis. *Applied Physics Research, 2*(1), 125–134.

Zellar, R., A. Pulkkinen, K. Moore, D. Reeb, E. Karakoylu, and O. Uritskaya. (2017). *Statistical Assessment of Cetacean Stranding Events in Cape Cod (Massachusetts, USA) Area OS21A-1345*. Greenbelt, MD: National Aeronautics and Space Administration.