3.5 Sea Turtles

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

3.5 SEA TURTLES

SEA TURTLES SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following have been analyzed for sea turtles:

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

Preferred Alternative (Alternative 1)[1]

- Acoustic: Pursuant to the Endangered Species Act (ESA), the use of sonar and other active acoustic sources may affect and is likely to adversely affect ESA-listed green, hawksbill, loggerhead, and leatherback sea turtles. The use of sonar and other active acoustic sources may affect but is not likely to adversely affect ESA-listed olive ridley sea turtles. The use of explosives may affect and is likely to adversely affect ESA-listed green and hawksbill sea turtles, but is not likely to adversely affect ESA-listed loggerhead, olive ridley, and leatherback sea turtles. The use of swimmer defense airguns would have no effect on ESA-listed green, hawksbill, loggerhead, olive-ridley, and leatherback sea turtles. Weapons firing, launch, and impact noise; vessel noise; and aircraft noise may affect but are not likely to adversely affect green, hawksbill, loggerhead, olive-ridley, and leatherback sea turtles.
- Energy: Pursuant to the ESA, energy sources used during training and testing activities may affect but are not likely to adversely affect the ESA-listed green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.
- Physical Disturbance and Strike: Pursuant to the ESA, physical disturbance and strike stressors may affect but are not likely to adversely affect the ESA-listed green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.
- Entanglement: Pursuant to the ESA, fiber optic cables and guidance wires, and decelerators/parachutes may affect but are not likely to adversely affect the ESA-listed green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.
- Ingestion: Pursuant to the ESA, the potential for ingestion of munitions and military expended materials other than munitions may affect but are not likely to adversely affect the ESA-listed green, hawksbill, loggerhead, olive ridley and leatherback sea turtles.
- Secondary: Pursuant to the ESA, secondary stressors would not affect sea turtles because changes in sediments and water quality from explosives, explosive byproducts and unexploded ordnance, metals, and chemicals are not likely to be detectable, and no detectable changes in growth, survival, propagation, or population-levels of sea turtles are anticipated.

[1]There is no critical habitat for any of the five listed sea turtles in the Study Area.

3.5.1 INTRODUCTION

This section analyzes potential impacts on sea turtles found in the Mariana Islands Training and Testing (MITT) Study Area (Study Area). Table 3.5-1 introduces the species presented in this analysis. Section 3.5.2 (Affected Environment) describes the affected environment. The analysis and summary of potential impacts of the Proposed Action are provided in Sections 3.5.3 (Environmental Consequences) and 3.5.4 (Summary of Impacts on Sea Turtles).

The status of sea turtle populations is determined primarily from assessments of the adult female nesting population. Much less is known about other life stages of these species. The National Research Council (National Research Council 2010) recently reviewed the current state of sea turtle research, and concluded that relying too much on nesting beach data limits a more complete understanding of sea turtles and the evaluation of management options for their overall health and recovery.

The five sea turtle species potentially found in the MITT Study Area are listed under the Endangered Species Act (ESA) as endangered or threatened. Section 3.0 discusses the regulatory framework of the ESA. The status, presence, and nesting occurrence of sea turtles in the MITT Study Area are listed by region in Table 3.5-1. There is no critical habitat for any of the five listed sea turtles in the Study Area.

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, 7]	
Common Name	**Scientific Name**	**Endangered Species Act Status**	**Open Ocean/Transit Corridor**	**Coastal**
Family Cheloniidae (hard-shelled sea turtles)				
Green sea turtle	*Chelonia mydas*	Endangered/ Threatened[2]	Yes	Yes[5]
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	Yes	Yes[5]
Loggerhead sea turtle	*Caretta caretta*	Endangered/ Threatened[3]	Yes[6]	Yes[6]
Olive ridley sea turtle	*Lepidochelys olivacea*	Endangered/ Threatened[4]	Yes[6]	Yes[6]
Family Dermochelyidae (leatherback sea turtle)				
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	Yes[6]	Yes[6]

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

[2] Breeding populations of green sea turtles in Florida and 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] The Northeast Atlantic Ocean, Mediterranean Sea, North Indian Ocean, North Pacific Ocean, and South Pacific Ocean Distinct Population Segments are listed as Endangered, and the Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean and Southwest Indian Ocean Distinct Population Segments are listed as threatened.

[4] Breeding populations of olive ridley 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.

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

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

[7] Occurrence designations from the Marine Species Density Report (U.S. Department of the Navy 2012).

3.5.2 Affected Environment

Sea turtles are highly migratory, and are present in coastal and open ocean waters of the Study Area. Most sea turtles generally inhabit tropical and temperate waters because they are poikilothermic, which means their internal temperature varies with the environment and they need a warm environment to help maintain body temperature. Leatherbacks are the exception, and are more likely to be found in colder waters at higher latitudes because of their unique ability to maintain an internal body temperature higher than that of the environment (Dutton 2006). Habitat use varies among species and within the life stages of individual species, correlating primarily with the distribution of preferred food sources, as well as the locations of nesting beaches.

Sea turtles use a variety of mechanisms and environmental cues to guide their movements on land and at sea (Lohmann and Lohmann 1996b; Lohmann et al. 1997; Putnam et al. 2011). Hatchlings are strongly attracted to light (Witherington and Bjorndal 1991), and use light wavelengths and shape patterns to find the ocean after emerging from the nest (Lohmann et al. 1997; Witherington 1992). Once in the ocean, hatchlings use wave energy to navigate offshore (Lohmann and Lohmann 1992). In the open ocean, turtles determine their position and direction by using the earth's magnetic field as a "magnetic map"; this map helps them locate seasonal feeding and breeding grounds and return to the beaches where they were born to nest (Fuxjager et al. 2011; Lohmann and Lohmann 2006; Lohmann et al. 1997). The stimuli that help sea turtles find their nesting beaches are still poorly understood, particularly the fine-scale navigation that occurs as turtles approach the site, and could also include chemical and acoustic cues.

Sea turtles produce large numbers of offspring as an evolutionary response to environmental variability, lack of parental care, and high levels of egg and hatchling mortality. Death is presumed to be highest during this phase of development, due to predation of eggs and hatchlings and because of ocean currents that sweep hatchlings into waters too cold for their survival (Conant et al. 2009). Depending on the species, open-ocean juveniles can spend 2–14 years drifting, foraging, and developing. The post-hatchling and early juvenile period has been described as "the lost years" because of a general lack of information about this part of their life history (Witham 1980) during which the turtles remain in oceanic waters, are free floating and opportunistically consume epipelagic prey (McClellan and Read 2007, Carr 1987, Bjorndal et al. 2000). Older juveniles remain in the open ocean, but are active feeders.

After this open ocean juvenile phase, hawksbill, loggerhead, and green sea turtles settle into coastal habitats, and are dedicated to a specific home range until adulthood (McClellan and Read 2007, Bjorndal and Bolten 1988, National Marine Fisheries Service and U.S. Fish and Wildlife Service 1991) Leatherback and olive ridley turtles are thought to remain primarily in the open ocean throughout their lives, except for when mating in coastal waters and when females come ashore to lay eggs. Adults of all species have the ability to migrate long distances across large expanses of the open ocean, primarily between nesting and feeding grounds.

Survival rates are believed to be highest during the adult stage because these turtles can protect themselves more effectively from predators; juveniles, while still at risk from predators and fishery interactions, are at less risk than hatchlings as they are generally not at risk from land-based and nearshore sources of mortality due to their open ocean use at the juvenile stage (Conant et al. 2009).

3.5.2.1 Diving

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). The diving behavior of a particular species or individual has implications for our ability to detect them for mitigation and monitoring. In addition their relative distribution through the water column is an important consideration when conducting acoustic exposure analyses. The following text briefly describes the dive behavior of each species.

3.5.2.1.1 Green Sea Turtle

Four Pacific Ocean studies (Brill et al. 1995; Hatase et al. 2006; I-Jiunn 2009; Rice and Balazs 2008) and one Atlantic study (Hays et al. 2000) assessed green turtle diving ability. Additional studies have been performed in the Galapagos (Seminoff et al. 2008), Brazil (Godley et al. 2008), Caribbean (Blumenthal et al. 2006), and Mediterranean (Godley et al. 2002). In the open ocean, Hatase et al. (2006) observed that green turtles dove to a maximum of 265 feet (ft.) (80.8 meters [m]), although typically no greater than 131 ft. (39.9 m). Green turtles migrating between the northwestern and main Hawaiian Islands reached a maximum depth greater than 445 ft. (135.6 m) at night (the deepest dives ever recorded for a green turtle) with a mean maximum night dive depth of 115 to 164 ft. (35 to 50 m) but only 14.1 ft. (4.3 m) during the day (Rice and Balazs 2008). In their coastal habitat, green turtles typically make dives shallower than 100 ft. (30.5 m) (Godley et al. 2002, Hatase et al. 2006, Hays et al. 2000, Hochscheid et al. 2005) and often do not exceed 55 ft. (16.8 m) (Hays et al. 2000; Rice and Balazs 2008), although they are known to feed and rest at depths of 65 to 165 ft. (19.8 to 50.3 m) (Balazs 1980; Brill et al. 1995).

Green turtle resting dives (i.e., more than 90 percent of dive time spent at maximum depth) can exceed 3.5 hours (Rice and Balazs 2008), but are generally less than 1 hour (I-Jiunn 2009). Feeding dives are shorter, with maximum durations of just over an hour, and average durations up to 30 minutes (Brill et al. 1995; I-Jiunn 2009).

3.5.2.1.2 Hawksbill Sea Turtle

Hawksbill foraging dive durations are often a function of turtle size, with larger turtles diving deeper and longer. Shorter and more active foraging dives occur predominantly during the day, while longer resting dives occur at night (Blumenthal et al. 2009; Storch et al. 2005; van Dam and Diez 1996). Lutcavage and Lutz (1997) cited a maximum dive duration of 73.5 minutes for a female hawksbill in the United States (U.S.) Virgin Islands. Van Dam and Diez (1996) reported foraging dives at a study site in the northern Caribbean ranged from 19 to 26 minutes at depths of 26.3 to 32.8 ft. (8.02 to 9.9 m), with resting night dives from 35 to 47 minutes. Foraging dives of immature hawksbills are shorter, ranging from 8.6 to 14.0 minutes, with a mean and maximum depth of 16.4 and 65.6 ft. (4.9 and 19.9 m), respectively (van Dam and Diez 1996). Blumenthal et al. (2009) reported consistent diving characteristics for juvenile hawksbill in the Cayman Islands, with an average daytime dive depth of 25 ft. (7.6 m) and a maximum depth of 140 ft. (42.7 m) and a mean nighttime dive depth of 15 ft. (4.6 m). A change in water temperature affects dive duration; cooler water temperatures in the winter result in increased nighttime dive durations (Storch et al. 2005).

3.5.2.1.3 Loggerhead Sea Turtle

Studies of loggerhead diving behavior indicate varying mean depths and surface intervals, depending on whether they were located in shallow coastal waters (short surface intervals) or in deeper, offshore areas (longer surface intervals) (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2009). Loggerhead diving behavior has been investigated in the Mediterranean (Godley et al. 2003, Casale et al. 2012) and the Caribbean (Blumenthal et al. 2006). Loggerhead turtles foraging in the nearshore habitat dive to the seafloor (average depth 165 to 490 ft. [50.3 to 149.4 m]) and those in the open-ocean habitat dive in the 0 to 80 ft. (0 to 24.4 m) depth range (Hatase et al. 2007). Dive duration was significantly longer at night and increased in warmer waters. Loggerhead turtles dived for longer and became more quiescent at lower temperatures, but as long as temperatures were above 10 degrees Celsius (°C), they retained their ability to move to another place or even to forage when they had the opportunity (Hochscheid et al. 2007).The average overall dive duration was 25 minutes, although dives exceeding 300 minutes were recorded. Turtles in the open-ocean habitat exhibited mid-water resting dives at around 45 ft. (13.7 m), where they could remain for many hours. This appears to be the main function of many of the night dives recorded (Hatase et al. 2007). Another study on coastal foraging loggerheads by Sakamoto et al. (1993) found that virtually all dives were shallower than 100 ft. (30.5 m).

Satellite telemetry data from 17 juvenile loggerhead turtles showed that turtles spent more than 80 percent of their time at depths less than 5 m, and more than 90 percent of their time at depths less than 15 m (Howell et al. 2010). Hawkes et al. (2007) noted that loggerhead turtles spent most of the time diving at depths less than 164 ft. (50 m) in depth. On average, loggerhead turtles spend over 90 percent of their time underwater (Renaud and Carpenter 1994). Studies investigating dive characteristics of loggerheads under various conditions confirm that loggerheads do not dive particularly deep in the open-ocean environment (approximately 80 ft. [24.4 m]) but will forage to bottom depths of at least 490 ft. (149.4 m) in coastal habitats (Hatase et al. 2007; Polovina et al. 2003).

3.5.2.1.4 Olive Ridley Sea Turtle

Most studies on olive ridley diving behavior have been conducted in shallow coastal waters (Beavers and Cassano 1996; Sakamoto et al. 1993); however, Polovina et al. (2003) radio tracked two olive ridleys (and two loggerheads) caught in commercial fisheries. The results show that the olive ridleys dove deeper than loggerheads, but spent only about 10 percent of time at depth deeper than 100 ft. (30.5 m). Daily dives of 656.2 ft. (200 m) occurred, with one dive recorded at 833.3 ft. (254 m) (Polovina et al. 2003). The deeper-dive distribution of olive ridleys is also consistent with their oceanic habitat, which differs from the loggerhead habitat. Olive ridleys are found south of the loggerhead habitat in the central portion of the subtropical gyre. The oceanography of this region is characterized by a warm surface layer with a deep thermocline depth and an absence of strong horizontal temperature gradients and physical or biological fronts (Polovina et al. 2003).

3.5.2.1.5 Leatherback Sea Turtle

The leatherback is the deepest diving sea turtle, with a recorded maximum depth of 4,200 ft. (1,280 m), although most dives are much shallower (usually less than 820 ft. [250 m]) (Doyle et al. 2008, Dodge et al. 2014, Houghton et al. 2008, Hays et al. 2004a, Sale et al. 2006). Leatherbacks are also capable of diving for a longer time than any other sea turtles species. The longest recorded dive time is 86.5 minutes, during which the turtle dove to a depth of 3,891 ft. (1,186 m) (López-Mendilaharsu et al. 2009). Diving activity (including surface time) is influenced by a suite of environmental factors (i.e., water temperature, availability and vertical distribution of food resources, bathymetry) that result in spatial and temporal variations in dive behavior (James et al. 2006, Sale et al. 2006). Leatherbacks dive deeper and longer in the lower latitudes versus the higher latitudes (James et al. 2005), where they are known to dive in waters with temperatures just above freezing (James et al. 2006, Jonsen et al. 2007). James et al. (2006) noted that dives in higher latitudes are punctuated by longer surface intervals and more time at the surface, perhaps in part to thermoregulate (i.e., bask). Tagging data also revealed that changes in individual turtle diving activity appear to be related to water temperature, suggesting an influence of seasonal prey availability on diving behavior (Hays et al. 2004a). While transiting, leatherbacks make longer and deeper dives (James et al. 2006, Jonsen et al. 2007). It is suggested that leatherbacks make scouting dives while transiting as an efficient means for sampling prey density and perhaps also to feed opportunistically at these times (James et al. 2006, Jonsen et al. 2007). In the Atlantic, Hays et al.

(2004b) determined that migrating and foraging adult leatherbacks spent 71 to 94 percent of their diving time at depths from 230 to 361 ft. (70.1 to 110 m).

In their warm-water nesting habitats, dives are likely constrained by bathymetry adjacent to nesting sites during this time (Myers and Hays 2006). For example, patterns of relatively deep diving are recorded off St. Croix in the Caribbean (Eckert et al. 1986) and Grenada (Myers and Hays 2006) in areas where deep waters are close to shore. A maximum depth of 1,560 ft. (475.5 m) was recorded by Eckert (Eckert et al. 1986), although even deeper dives were inferred where dives exceeded the maximum range of the time depth recorder (Eckert S. et al. 1989). Shallow diving occurs where shallow water is close to the nesting beach in areas such as the China Sea (Eckert et al. 1996, Chan et al. 2007), Costa Rica (Southwood et al. 1999), and French Guiana (Fossette et al. 2007). Studies of leatherback diving during their internesting periods (i.e., time intervals spent at sea between consecutive nesting events) in the Eastern Pacific show shallower maximum dive depths than in other areas where deeper water is available (Wallace et al. 2005).

3.5.2.2 Hearing and Vocalization

The auditory system of the sea turtle appears to work via water and bone conduction, with lower frequency sound conducted through to skull and shell, or via direct stimulation of the tympanum (Christensen-Dalsgaard et al. 2012).The water and bone conduction does not appear to function well for hearing in air (Lenhardt et al. 1983), though recent research has shown that sea turtles are capable of hearing in air, and although it is difficult to compare aerial and underwater thresholds directly, frequencies of sensitivity are similar for several species tested (Dow Piniak et al. 2011, 2012a, 2012b).

Sea turtles do not have external ears or ear canals to channel sound to the middle ear, nor do they have a specialized eardrum. Instead, fibrous and fatty tissue layers on the side of the head may serve as the sound receiving membrane in the sea turtle (Ketten 2008), a function similar to that of the eardrum in mammals, or may serve to release energy received via bone conduction (Lenhardt et al. 1983). Sound is transmitted to the air-filled middle ear where sound waves cause movement of cartilaginous and bony structures that interact with the inner ear (Ridgway et al. 1969). Unlike mammals, the cochlea of the sea turtle is not elongated and coiled and likely does not respond well to high frequencies, a hypothesis supported by a limited amount of information on sea turtle auditory sensitivity (Martin et al. 2012; Lavender et al. 2011; Dow Piniak et al. 2011, 2012a, 2012b; Bartol et al. 1999; Ridgway et al. 1969).

Investigations suggest that sea turtle auditory sensitivity is limited to low-frequency bandwidths (< 1,000 Hertz [Hz]), such as the sounds of waves breaking on a beach. The role of underwater low-frequency hearing in sea turtles is unclear. It has been suggested that sea turtles may use acoustic signals from their environment as navigational cues during migration and to identify their natal beaches (Lenhardt et al. 1983) or to locate prey or avoid predators.

Recent work using auditory evoked potentials have shown that hawksbill sea turtles are able to detect sounds in both air and water. However, ranges of maximum sensitivity and thresholds differed between the two media, though in general, sensitivities were higher at frequencies below 1,000 Hz (Dow Piniak et al. 2011, 2012b).

Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol 1999, Ridgway 1969, Lenhardt 1994, Bartol and Ketten 2006, Lenhardt 2002). Hearing below 80 Hz is less sensitive but still potentially usable (Lenhardt 1994). Greatest sensitivities are from 300 to 400 Hz for the green sea turtle (Ridgway 1969) and around 250 Hz or below for juvenile loggerheads (Bartol 1999). Bartol et al. (1999) reported that the range of effective hearing for juvenile loggerhead sea turtles is from at least 250 to 750 Hz using the auditory brainstem response technique. Juvenile and sub-adult green sea turtles detect sounds from 100 to 500 Hz underwater, with maximum sensitivity at 200 and 400 Hz (Bartol and Ketten 2006). Auditory brainstem response recordings on green sea turtles showed a peak response at 300 Hz (Yudhana et al. 2010). Juvenile Kemp's ridley turtles detected underwater sounds from 100 to 500 Hz, with a maximum sensitivity between 100 and 200 Hz (Bartol and Ketten 2006). Recent work using auditory evoked potentials has shown that leatherback sea turtles are able to detect sounds in both air and water. However, ranges of maximum sensitivity and thresholds differed between the two media—between 50 and 1,200 Hz in water and 50 and 1,600 Hz in air, with maximum sensitivity between 100 and 400 Hz in water and 50 and 400 Hz in air, and sharp decreases in sensitivity above 400 Hz in both media (Dow Piniak et al. 2012a).

Sub-adult green sea turtles show, on average, the lowest hearing threshold at 300 Hz (93 decibels [dB] referenced to [re] 1 micropascal [µPa]), with thresholds increasing at frequencies above and below 300 Hz, when thresholds were determined by auditory brainstem response (Bartol and Ketten 2006). Auditory brainstem response testing was also used to detect thresholds for juvenile green sea turtles (lowest threshold 93 dB re 1 µPa at 600 Hz) and juvenile Kemp's ridley sea turtles (thresholds above 110 dB re 1 µPa across hearing range) (Bartol and Ketten 2006). Auditory thresholds for yearling and 2-year-old loggerhead sea turtles were also recorded. Both yearling and 2-year-old loggerhead sea turtles had the lowest hearing threshold at 500 Hz (yearling: approximately 81 dB re 1 µPa; 2-year-olds: approximately 86 dB re 1 µPa), with thresholds increasing rapidly above and below that frequency (Bartol and Ketten 2006). In terms of sound production, nesting leatherback turtles were recorded producing sounds (sighs or belch-like sounds) up to 1,200 Hz with most energy ranging from 300 to 500 Hz (Bartol and Ketten 2006).

Popper et al. (2014) summarized in a technical report the outcome of a working group session that evaluated the sound detection capabilities for a wide range of sea turtles and fishes, which were organized into broad groups based on how they detect sound. The technical report presents sound exposure guidelines for assessing how a variety of natural and anthropogenic sound sources may affect fish and sea turtle species.

In terms of sound production, nesting leatherback turtles have been recorded producing sounds (sighs or belch-like sounds) up to 1,200 Hz with most energy ranging from 300 to 500 Hz (Cook and Forrest 2005). These noises are guttural exhalations made during the nesting process; turtles do not make audible sounds for communication, navigation, or foraging (as in marine mammals).

3.5.2.3 General Threats

While each of the sea turtle species in the MITT Study Area have unique life histories and habitats, threats are common among all species. On beaches, wild dogs, pigs, and other animals destroy sea turtle nests. Humans continue to harvest eggs and nesting females in some parts of the world, threatening some Pacific Ocean sea turtle populations (Maison et al. 2010). Coastal development can cause beach erosion and introduce non-native vegetation, leading to a subsequent loss of nesting habitat. It can also introduce or increase the intensity of artificial light, which can impact nesting behavior of adult females or confuse hatchlings and lead them away from the water, thereby increasing the chances of hatchling mortality. Threats in nearshore foraging habitats include fishing activities and habitat degradation. Fishing activities can injure turtles via hooks and lines or drown juvenile and adult sea turtles, because they are prone to becoming entangled in fishing gear and nets. Habitat degradation issues such as poor water quality, invasive species, and disease can alter ecosystems, limiting the availability of food and altering survival rates (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998a, b, c, d, e, f).

Bycatch in commercial fisheries, ship strikes, and marine debris are the primary, human related threats in the offshore environment (Lutcavage and Lutz 1997). One comprehensive study estimated that, worldwide, approximately 85,000 turtles were taken between the years of 1990 and 2008 from bycatch in commercial fisheries (Wallace et al. 2010). However, due to the small percentage of fishing effort observed and reported (typically < 1 percent of total fleets), and to a global lack of bycatch information from small-scale fisheries, this likely underestimates the true total by at least two orders of magnitude. Precise data are lacking for sea turtle mortalities directly caused by ship strikes; however, live and dead turtles are often found with deep cuts and fractures indicative of collision with a boat hull or propeller (Hazel et al. 2007; Lutcavage and Lutz 1997). Marine debris can also be a problem for sea turtles through entanglement or ingestion. Sea turtles can mistake plastic bags for jellyfish, which are eaten by many turtle species in early life phases, and exclusively by leatherback turtles throughout their lives. One study found plastic in 37 percent of dead leatherbacks and determined that 9 percent of those deaths were a direct result of plastic ingestion (Mrosovsky et al. 2009). Other marine debris, including derelict fishing gear and cargo nets, can entangle and drown turtles of all life stages. In studying ingestion in 115 green and hawksbill sea turtles stranded in Queensland, Schuyler et al. (2012) found that the probability of debris ingestion was inversely correlated with size (curved carapace length), and when broken down into size classes, smaller pelagic turtles were significantly more likely to ingest debris than larger benthic feeding turtles.

Global climate change trends, with predictions of increased ocean and air temperatures, showing increasing acidification of oceans, and sea level rise, may adversely impact turtles in all life stages Schofield et al. 2010, Witt et al. 2010, Hawkes et al. 2009, Poloczanska et al. 2009, Fuentes et al. 2011). Effects include embryo deaths caused by high nest temperatures, skewed sex ratios because of increased sand temperature, loss of nesting habitat to beach erosion, coastal habitat degradation (e.g., coral bleaching), and alteration of the marine food web, which can decrease the availability of prey species. Each sea turtle recovery plan has detailed descriptions of threats in the nesting and marine environment, ranking the seriousness of threats in each of the U.S. Pacific coast states and territories (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998a, b, c, d, e, f). See Chapter 4 (Cumulative Impacts) for further descriptions of threats to sea turtles and ongoing conservation concerns.

3.5.2.4 Green Sea Turtle (*Chelonia mydas*)

3.5.2.4.1 Status and Management

Green turtles are classified as threatened under the ESA throughout their Pacific range, except for the population that nests on the Pacific coast of Mexico (identified by the National Marine Fisheries Service [NMFS] and U.S. Fish and Wildlife Service [USFWS] [1998b] as *[C. m.] agassizii*), which is classified as endangered. There is no critical habitat for the green sea turtle in the Study Area.

3.5.2.4.2 Habitat and Geographic Range

The green turtle is distributed worldwide across tropical and subtropical coastal waters between 45° North (N) and 40° South (S) (State of the World's Sea Turtles 2012). Major nesting beaches are found throughout the western and eastern Atlantic, Indian, and western Pacific Oceans, and are found in more than 80 countries worldwide (Hirth 1997). Green turtles nest on beaches of the Mariana Islands, and feed and migrate throughout all waters of the Study Area.

Green turtle eggs incubate in the sand for approximately 48 to 70 days. Green turtle hatchlings are 2 inches (in.) (5.08 centimeters [cm]) long, and weigh approximately 1 ounce (oz.) (28.3 grams [g]).

3.5.2.4.2.1 Open Ocean

When they leave the nesting beach, hatchlings begin an oceanic phase (Carr 1987), floating passively in current systems (gyres), where they develop (Carr and Meylan 1980). Post-hatchlings live at the surface in the open ocean for approximately 1 to 3 years (Hirth 1997). Reich et al. (2007) used stable isotope analyses to demonstrate recruitment of oceanic juvenile green turtles to neritic habitats (in the western Atlantic) at around 3 years of age. Upon reaching the juvenile stage (estimated at 5 to 6 years and shell length of 8 to 10 in. [20.3 to 25.4 cm]), they actively move to lagoons and coastal areas that are rich in seagrass and algae (Bresette et al. 2006; Musick and Limpus 1997; Limpus 2008). The optimal habitats for late juveniles and adults are warm, quiet, and shallow (10 to 33 ft. [3.05 to 10.1 m]) waters, with seagrasses and algae that are near reefs or rocky areas used for resting (Makowski et al. 2006). This habitat is where they will spend most of their lives (Bjorndal and Bolten 1988; Makowski et al. 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 1991). A small number of green turtles appear to remain in the open ocean for extended periods, perhaps never moving to coastal feeding sites, though the reasons for this behavior is not yet understood (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a; Pelletier et al. 2003).

Green turtles are highly migratory throughout their lives. They may travel thousands of kilometers (km) between their juvenile developmental grounds and adult breeding and nesting grounds (Mortimer and Portier 1989). When they reach sexual maturity, green turtles begin migrating regularly between feeding grounds and nesting areas every few years (Hirth 1997). Green turtles are estimated to reach sexual maturity at between 20 and 50 years. This prolonged time to maturity has been attributed to their low energy plant diet (Bjorndal 1995) and may be the highest age for maturity of all sea turtle species (Limpus 2008, Chaloupka and Musick 1997, Hirth 1997, National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a). Once mature, green turtles may reproduce for 17 to 23 years (Carr et al. 1978). Both males and females migrate, typically along coastal routes from breeding areas to feeding grounds, although some populations migrate thousands of kilometers across entire oceans (Carr 1986, 1987; Mortimer and Portier 1989). Following nesting migrations, green turtles often return to the same feeding areas (Godley et al. 2002; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a) where they have specific home ranges and movement patterns (Seminoff et al. 2002). Sea turtle tagging successfully began in 2013 under the monitoring program and preliminary results are within the U.S. Department of the Navy's (Navy's) 2014 annual report to NMFS.

3.5.2.4.2.2 Coastal

Green sea turtles return to their nesting (natal) beaches to nest every 2 to 5 years (Hirth 1997). This irregular pattern can cause wide year-to-year changes in numbers of nesting females at a given nesting beach. Each female nests between three and five times per season, laying an average of 115 eggs in each nest. Based on an average of three nests per season and 100 eggs per nest, a single adult female may deposit 9 to 33 clutches (900 to 3,300 eggs) during her lifetime (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b). The number of eggs per clutch is a function of when in the season it is laid. Larger clutches tend to be laid in the early part of the breeding season (Limpus 2008).

On Navy lands on Guam, the beach with the highest nesting abundance is Apra Harbor's Spanish Steps, which is closed for most of the year because of explosive safety arcs from Kilo Wharf. Green sea turtle nesting activity was also found at Adotgan Dangkolo on Orote Peninsula. Haputo Beach, Naval Base Guam Telecommunications Site, is an occasional nesting location with "extensive" foraging use within the Haputo embayment. On Andersen Air Force Base, the Division of Aquatic and Wildlife Resources has monitored sea turtle nesting activity on the 26 miles (mi.) (42 km) of shoreline that make up Andersen Air Force Base beaches since 1984. Nesting at Andersen Air Force Base occurs along the northern shoreline. Nesting surveys have indicated that adult green turtles utilize most, if not all, of the limited beaches on Tinian for nesting. The beaches that are most often utilized are Unai Dankulo (Long Beach), Unai Barcinas, Unai Leprosarium, and Unai Lamlam (U.S. Department of the Navy 2010).

3.5.2.4.3 Population and Abundance

Based on data from 46 nesting sites around the world, between 108,761 and 150,521 female green sea turtles nest each year (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a), which is a 48 to 65 percent decline in the number of females nesting annually (based on a simple linear regression rather than historical abundance observations) over the past 100 to 150 years (Seminoff and Marine Turtle Specialist Group Green Turtle Task Force 2004). At least 189 nesting sites are scattered across the western Pacific Ocean, with an estimated 22,800 to 42,580 females nesting in the Pacific Ocean each year (Maison et al. 2010; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a).

Data from 32 green turtle nesting sites throughout the nesting range estimated that over the last three generations (spanning approximately 130 years), female green turtles have declined globally by 48 to 67 percent (Seminoff and Marine Turtle Specialist Group Green Turtle Task Force 2004). However, and in contrast, many green turtle nesting populations are actually on the increase as a result of direct conservation action and are not under threat of extinction. Chaloupka et al. (2008a) provides evidence of increasing population trends in four major green turtle nesting populations in the Pacific that have been increasing over the past 25 years (Hawaii, USA; Raine Island and Heron Island, Australia; and Ogawasara Islands, Japan). Tiwari et al. (2010) provide information on nesting data in the Main Hawaiian Islands that also support the increasing population trend. Historically, the Philippines (Turtle Islands) and Turtle Islands Park of Sabah, Malaysia are two of the most important insular nesting colonies in Southeast Asia (Seminoff and Marine Turtle Specialist Group Green Turtle Task Force 2004). There is evidence to suggest that green turtle populations nesting in Sabah are stable or increasing, with trends from 1993 to 2001 showing a continued upward trend (Bastinal 2002; Seminoff and Marine Turtle Specialist Group Green Turtle Task Force 2004). Nesting in the Philippines has declined over time, although there are over 3,000 nesting females per year (Seminoff and Marine Turtle Specialist Group Green Turtle Task Force 2004). Additionally, there appears to be a robust green turtle nesting population in Yap State, Federated States of Micronesia with a total of 888 individual nesting green turtles tagged on Gielop Island between 2005 and 2007 (Maison et al. 2010). It is important to note, however, that increases in population abundance at individual nesting sites do not necessarily reflect population-level increases in abundance.

Green turtles are by far the most abundant sea turtle found throughout the Marianas archipelago. At least 189 nesting sites are scattered across the western Pacific Ocean, with an estimated 22,800–42,580 females nesting in the Pacific Ocean each year (Maison et al. 2010; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a). Long-term information regarding nesting population trends in Guam or Commonwealth of the Northern Mariana Islands is not available. There is, however, indication that the Marianas may provide more important foraging nearshore habitat than nesting (Kolinski et al.

2001; Pultz et al. 1999). Aerial surveys conducted by the Guam Division of Aquatic and Wildlife Resources indicate the year-round presence of green sea turtles in Guam's nearshore waters (Kolinski et al. 2001, National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998a, Pultz et al. 1999). Recent Navy surveys have estimated the nearshore density to be approximately 1 animal per 3.4 square kilometers (km^2) (1.31 square miles [$mi.^2$]) (excluding within Apra Harbor, where density is much higher, variable, and more finite in resolution). Aggregations of foraging and resting green turtles are often seen in close proximity to Guam's well-developed seagrass beds and reef flats, which are found in Cocos Lagoon, Apra Harbor, along Tarague Beach and Hila'an; in deeper waters south of Falcona Beach; and at several other locations throughout the island's shelf (U.S. Department of the Navy 2003b). Recreational Self Contained Underwater Breathing Apparatus (SCUBA) divers regularly see green turtles at the following sites off Guam: Boulder Alley, Ane Caverns, Napoleon Cut, Gab Gab I, and the Wall. Guam Division of Aquatic and Wildlife Resources aerial surveys have identified turtles within Agat Bay, and stranded sea turtles have been recovered from the bay (including one with spear gun injuries).

On Tinian, green turtle abundance and densities are highest along the island's relatively uninhabited east coast. The most recent estimate of the number of green turtles inhabiting the nearshore waters around Tinian was 832 turtles in 2001 (Kolinski et al. 2006) and densities of approximately 11.8 animals per km^2.

Green turtles are not as abundant at Farallon de Medinilla (FDM) as they are at some of the larger islands of the Marianas chain. At FDM, at least 9 green turtles were observed during underwater surveys in both 1999 and 2000, at least 12 green turtles were observed during surveys in 2001, and 4 were observed at the northern end of the island in 2003 (U.S. Department of the Navy 2005). Most green turtles at FDM were found either swimming over the reef platform or resting in holes or caves (U.S. Department of the Navy 2005). Due to strong current and tidal conditions, the beaches at FDM are very susceptible to inundation and are highly unsuitable for nesting (U.S. Department of the Navy 2003a). Also, seagrasses and benthic algae are relatively sparse around the island and can probably support no more than a few green turtles at a time (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998a). Seven sea turtles were documented in 2006 and 19 in 2007 during monthly monitoring (helicopter surveys) of FDM (U.S. Department of the Navy 2010). Monthly observations are usually low (between one and three turtle sightings); however, 12 turtles were observed in waters off FDM on 13 November 2007 (U.S. Department of the Navy 2010). Identifying sea turtles to the species level is not possible due to safe flying heights of the helicopter, although due to the higher abundance of green sea turtles relative to hawksbill turtles, the majority of sea turtle observations are assumed to be green sea turtles (U.S. Department of the Navy 2010).

Based on the above information, green turtles are expected to occur year round in all shelf waters of the MITT Study Area from FDM to Guam. Around the larger islands, green turtle occurrence is concentrated in waters less than 328 ft. (99.9 m) deep, approximately 11.8 animals per km^2 (4.6 $mi.^2$). It is at these water depths where green turtle foraging and resting habitats (e.g., fringing reefs, reef flats, and seagrass beds) are usually found. Although there may not be long-term data available for Guam or Commonwealth of the Northern Mariana Islands, data from other Pacific regions show that green sea turtles exhibit strong site fidelity to nearshore foraging habitats for extended periods of time (Balazs and Chaloupka 2004; Balazs 1994). Beyond the shelf break, green turtle occurrence is low/unknown, and assumed to be approximately 1 animal per 2.558 km^2 (0.988 $mi.^2$) (U.S. Department of the Navy 2012). Nesting females and early juveniles are known to move through oceanic waters of the Marianas chain during their reproductive and developmental migrations (Kolinski et al. 2006), but likely do not do so in large numbers.

3.5.2.4.4 Predator-Prey Interactions

The green turtle is the only sea turtle that is mostly herbivorous (Mortimer 1995), although its diet changes throughout its life. While at the surface, hatchlings feed on floating patches of seaweed and, at shallow depths, on comb jellies and gelatinous eggs, appearing to ignore large jellyfish (Salmon et al. 2004). While in the open ocean, juveniles smaller than 8 to 10 in. (20.3 to 25.4 cm) eat worms, small crustaceans, aquatic insects, grasses, and algae (Bjorndal 1997). After settling into a coastal habitat, juveniles eat mostly seagrass or algae (Balazs et al. 1994; Mortimer 1995). Some juveniles and adults that remain in the open ocean, and even those in coastal waters, also consume jellyfish, sponges, and sea pens (Blumenthal et al. 2009; Godley et al. 1998; Hatase et al. 2006, Heithaus et al. 2002; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b; Parker and Balazs 2005). Adult green turtles feed primarily on seagrasses, macroalgae, and reef-associated organisms (Bjorndal 1997; Burke et al. 1991). They also consume jellyfish, salps, and sponges (Bjorndal 1997).

Predators of green turtles vary according to turtle location and size. Land predators that feed on eggs and hatchlings include ants, crabs, birds, and mammals, such as dogs, raccoons, feral pigs, and humans. Aquatic predators, mostly fish and sharks, impact hatchlings most heavily in nearshore areas. Sharks are also the primary predators of juvenile and adult turtles (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a).

3.5.2.4.5 Species-Specific Threats

The primary, human related threats to green turtles in Guam and the Commonwealth of the Northern Mariana Islands include direct harvesting of sea turtles and eggs as well as habitat loss due to rapidly expanding tourism, including increased coastal development on nesting beaches (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998a, b). Another primary threat to green turtles that may be related to human activity is the disease fibropapillomatosis. Fibropapillomatosis may be caused by exposure in marine areas affected by agricultural, industrial, or urban pollution (Aguirre and Lutz 2004); however, Chaloupka et al. (2009) noted that the occurrence of fibropapillomatosis appears to be declining. Other general threats include habitat degradation by ungulates and nest predation by pigs, feral dogs, cats, and rats, as well as destruction of strand vegetation, compaction of sand on nesting beaches by vehicles and heavy equipment, and the use of excessive or inappropriate lighting on beaches.

3.5.2.5 Hawksbill Sea Turtle (*Eretmochelys imbricata*)

3.5.2.5.1 Status and Management

The hawksbill turtle is listed as endangered under the ESA (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c). In U.S. waters, hawksbill populations are noted as neither declining nor showing indications of recovery (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b). Critical habitat has not been designated for the hawksbill in the Pacific Ocean.

3.5.2.5.2 Habitat and Geographic Range

The hawksbill turtle is the most tropical of the world's sea turtles, rarely occurring beyond 30°N or 30°S in the Atlantic, Pacific, and Indian Oceans (Lazell 1980). While the hawksbill turtle lives a part of its life (post-hatchling and early juvenile) in the open ocean, it inhabits coastal waters in more than 108 countries (where it feeds on its preferred prey, sea sponges) and nests in at least 70 countries (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b).

3.5.2.5.2.1 Open Ocean

Hawksbill turtles inhabit oceanic waters as post-hatchlings and small juveniles, where they are sometimes associated with driftlines and floating patches of vegetation (Parker 1995; Limpus 2009; Witherington and Hirama 2006). As with all other turtle species, hawksbill hatchlings enter an oceanic phase (known as the “lost years”) and may be carried great distances by surface currents. Although little is known about their open ocean stage, younger juvenile hawksbills have been found in association with brown algae in the Pacific Ocean (Musick and Limpus 1997; Parker 1995; Witherington and Hirama 2006; Witzell 1983) before settling into nearshore habitats as older juveniles.

3.5.2.5.2.2 Coastal

The developmental habitats for juvenile benthic-stage hawksbills include tropical, nearshore waters associated with coral reefs, hard bottoms, or estuaries with mangroves (Musick and Limpus 1997). Coral reefs are recognized as optimal hawksbill habitat for juveniles, subadults, and adults (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c). In nearshore habitats, resting areas for late juvenile and adult hawksbills are typically located in deeper waters than their foraging areas, such as sandy bottoms at the base of a reef flat. Late juveniles generally reside on shallow reefs less than 59 ft. (17.9 m) deep.

Preferred habitat for older juvenile hawksbill turtles is coral reefs, but hawksbills also inhabit seagrass, algal beds, mangrove bays, creeks, and mud flats (Mortimer and Donnelly 2008). Some juveniles may associate with the same feeding grounds for a decade or more (Meylan and Donnelly 1999), while others appear to migrate among multiple sites as they age (Musick and Limpus 1997). Indo-Pacific hawksbills are estimated to mature between 30 and 38 years old (Mortimer and Donnelly 2008).

As they mature into adults, hawksbills move to deeper habitats and may forage to depths greater than 297 ft. (90.5 m), though recent studies have shown that in the eastern tropical Pacific, some adults may continue to use nearshore estuaries and mangroves saltwater forests (Gaos 2011). Benthic stage hawksbills are seldom found in waters beyond the continental or insular shelf, unless they are in transit between distant foraging and nesting grounds (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c).

Once sexually mature, hawksbill turtles undertake breeding migrations between foraging grounds and breeding areas at intervals of several years (Dobbs et al. 1999, Witzell 1983). Although females tend to return to breed where they were born (Bowen and Karl 1997), they may have foraged hundreds or thousands of kilometers from their birth beaches as juveniles. Hawksbills were originally thought to be a nonmigratory species because of the proximity of suitable nesting beaches to coral reef feeding habitats and the high rates of marked turtles recaptured in these areas. Tagging studies have demonstrated that the adult female displays a high degree of fidelity to her chosen nesting beach, with most females returning to the same small beach for oviposition of their successive clutches within a nesting season and in successive nesting seasons (Limpus 2009). Some additional tagging studies have shown otherwise. For example, a post-nesting female traveled 995 mi. (1,601.3 km) between the Solomon Islands and Papua New Guinea (Meylan 1995), indicating that adult hawksbills are capable of migrating distances comparable to those of green and loggerhead turtles.

Hawksbills are solitary nesters on beaches throughout the tropics and subtropics. Adult female hawksbills return to their natal beaches every 2 to 3 years to nest. A female hawksbill lays between three and five clutches during a single nesting season, which contain an average of 130 eggs per clutch (Richardson et al. 1999). Hawksbills are unlikely to be encountered on the beaches of FDM, which are unsuitable for nesting because of tidal inundation of beach areas (U.S. Department of the Navy 2003b). There are only a few documented records of hawksbills nesting in the Marianas region although only a subset of the region's beaches is adequately surveyed for sea turtle nesting activity.

3.5.2.5.3 Population and Abundance

Nesting beach observations for hawksbill turtles in the Pacific Ocean have shown numerous nesting locations of hawksbills in the Pacific, with regional nesting occurring in Australia, Papau New Guinea, Palau, and Indonesia (State of the World's Sea Turtles 2012). Only five regional populations worldwide remain with more than 1,000 females nesting annually (two in Australia and one each in Indonesia, the Seychelles, and Atlantic Mexico) (Meylan and Donnelly 1999). The largest of these regional populations is in the South Pacific Ocean, where 6,000 to 8,000 hawksbills nest off the Great Barrier Reef (Limpus 1992).

Although there are only a few recent hawksbill occurrence records in the MITT Study Area (U.S. Department of the Navy 2003b), historical records indicate a likely presence of this species in the coastal waters surrounding the islands of the southern Marianas arc (i.e., from FDM south to Guam) (Kolinski et al. 2001). As a result, hawksbill turtles are expected to occur in all waters located inside the shelf break within the MITT Study Area, including within Guam's Apra Harbor. Since hawksbill turtles are critically endangered and do not occur in large numbers anywhere within the region, there are no areas of concentrated occurrence around Guam and the Commonwealth of the Northern Mariana Islands. In deeper waters beyond the shelf break (e.g., throughout Warning Area 517), the occurrence of the hawksbill turtle is low/unknown.

During aerial surveys between 1989 and 1991, hawksbills represented 13.2 percent of all sea turtles sighted around Guam. Hawksbills are typically found near river mouths as well as inside Apra Harbor. These are areas where sponges, their preferred food, are common. Sasa Bay, which is located in Apra Harbor, is the largest estuary in the Marianas, and appears to be an area where hawksbills are most often encountered (Kolinski et al. 2001).

Hawksbill turtles are also regular inhabitants of Tinian nearshore waters, although in much fewer numbers than green turtles, with recent surveys in 2013 observing two hawksbill turtles on the west coast of Tinian. Hawksbills typically display small home ranges, less than 4 km^2; however, one hawksbill turtle in the study was observed making a 286 km, 7-day trek from Tinian to Guam (Jones and Van Houtan 2013). Even though past surveys at Tinian (1984–1985, 1994–1995, and 2001) failed to produce a single sighting record, time and area constraints may have led to foraging hawksbills being missed (Kolinski et al. 2001; Pultz et al. 1999). Since hawksbills prefer to nest in areas with sufficient vegetative cover, it is possible that some nests are never found on surveyed beaches. Lund (1985) notes that hawksbill nests are often very difficult to identify when qualified observers are not present. Recent surveys by the Navy estimates the nearshore density of hawksbill turtles at Tinian and other Islands (excluding FDM) at 1 hawksbill turtle per 7.45 km^2 (2.88 $mi.^2$).

Occurrence records that exist for FDM are two in-water sightings at the southwestern corner of the island in 2001, and one at the northwest corner of the island in 2004 (U.S. Department of the Navy 2003b, 2004). Each of these observations was recorded during Navy-sponsored marine tow and SCUBA dive surveys around the island. Both of the hawksbills sighted in 2001 were immature individuals less than 20 in. (50.8 cm) in carapace length, while the individual observed in 2004 was somewhat larger at approximately 28 in. (71.1 cm) in carapace length (U.S. Department of the Navy 2004). The Pacific Navy Marine Species Density Database indicates a higher density at FDM than at other islands, approximately

1 hawksbill per 0.932 km^2 (0.36 $mi.^2$) in waters less than 100 m (328.1 ft.) deep (U.S. Department of the Navy 2012).

3.5.2.5.4 Predator-Prey Interactions

Hawksbills eat both animals and plants during the early juvenile stage, feeding on such prey as sponges, algae, mollusks, crustaceans, and jellyfish (Bjorndal 1997). Older juveniles and adults are more specialized, feeding primarily on sponges, which comprise as much as 95 percent of their diet in some locations, although the diet of adult hawksbills in the Indo-Pacific region includes other invertebrates and algae (Meylan 1988; Witzell 1983). The shape of their mouth allows hawksbills to reach into holes and crevices of coral reefs to find sponges and other invertebrates. Hawksbill turtles fill a unique ecological niche in marine and coastal ecosystems, supporting the natural functions of coral reefs by keeping sponge populations in check (Hill 1998, Leon and Bjorndal 2002). Feeding on sponges helps to control populations of sponges that may otherwise compete for space with reef-building corals (Hill 1998, Leon and Bjorndal 2002).

Predators of hawksbills vary according to turtle location and size. Land predators on eggs and hatchlings include ants, crabs, birds, and mammals, such as dogs, raccoons, and feral pigs. Aquatic predators, mostly fish and sharks, impact hatchlings most heavily in nearshore areas. Sharks are also the primary predators of juvenile and adult turtles (Stancyk 1982).

3.5.2.5.5 Species-Specific Threats

The hawksbill shell has been prized for centuries by artisans and their patrons for jewelry and other adornments. This trade, prohibited under the Convention on International Trade in Endangered Species of Wild Fauna and Flora, remains a critical threat to the species (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b).

An additional threat to hawksbill sea turtles is loss of nesting habitat caused by the expansion of resident human populations in coastal areas of the world, as well as the increased destruction or modification of coastal ecosystems to support tourism (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c). Coastal pollution as a result of increased development degrades water quality, particularly coral reefs, which are primary foraging areas for hawksbills.

3.5.2.6 Loggerhead Sea Turtle (*Caretta caretta*)

3.5.2.6.1 Status and Management

In a September 2011 rulemaking, the NMFS and USFWS determined that the loggerhead sea turtle is composed of nine distinct population segments, four listed as threatened (Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean, and Southwest Indian Ocean) and five as endangered (Northeast Atlantic Ocean, Mediterranean Sea, North Indian Ocean, North Pacific, and South Pacific) under the ESA to be effective 24 October 2011. No critical habitat is listed for the loggerhead, but the rulemaking indicated that critical habitat be designated after any listing revision (76 FR 58868).

3.5.2.6.2 Habitat and Geographic Range

The loggerhead is found in temperate to tropical regions and is generally found between 40°N and 40°S of the Atlantic, Pacific, and Indian Oceans and in the Mediterranean Sea (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007d). The loggerhead turtle is found in habitats ranging from coastal estuaries to the open ocean (Dodd 1988). The species may be found hundreds of miles out to sea, as well as in nearshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. The nearshore juvenile stage and adult foraging stage both occur in the nearshore zone. Coral reefs, rocky places, and ship wrecks are often used as feeding areas. The loggerhead turtles here are active and feed primarily on the bottom (epibenthic/demersal), though prey is also captured throughout the water column (Bjorndal 2003). The nearshore zone not only provides crucial foraging habitat, but can also provide inter-nesting and overwintering habitat. Tagging data revealed that migratory routes may be coastal or may involve crossing deep ocean waters (Peckham et al. 2007); an oceanic route may be taken even when a coastal route is an option (Schroeder et al. 2003).

3.5.2.6.2.1 Open Ocean

Loggerheads spend the first 7–11.5 years of their lives in the open ocean (Bjorndal et al. 2000). After hatchlings travel to oceanic habitats, they are often found in seaweed drift lines. Juvenile loggerhead turtles of the North Pacific occur in one of at least two distinct habitats for extended periods, the oceanic waters of the central North Pacific and the nearshore waters of the Baja California peninsula (Kobayashi et al. 2008). In the western North Pacific, Polovina et al. (2004) and Parker and Balazs (2005) found that juvenile and adult loggerheads (both in the western North Pacific Ocean) swim against weak prevailing currents because they are attracted to areas of high productivity. Similar observations have been made in the Atlantic (Hawkes et al. 2006). These results suggest that the location of currents and associated frontal eddies is important to the loggerhead's foraging during its open ocean stage (Mansfield et al. 2009; McClellan and Read 2007).

3.5.2.6.2.2 Coastal

At about 14 years old, some juveniles move to nearshore habitats close to their natal area, while others remain in the oceanic habitat or move back and forth between the two (McClellan and Read 2007, Mansfield et al. 2009, Musick and Limpus 1997). Turtles may use the same nearshore developmental habitat all through maturation or may move among different areas, finally settling in an adult foraging habitat. Loggerheads reach sexual maturity at around 35 years of age and move from subadult to adult coastal foraging habitats (Godley et al. 2003; Musick and Limpus 1997). Data from Japan (Hatase et al. 2002), Cape Verde (Hawkes et al. 2006), and Florida (Reich et al. 2007) indicate that at least some of the adult population forage in the open ocean.

Loggerheads typically nest on beaches close to reef formations and adjacent to warm currents (Dodd 1988). They prefer nesting beaches facing the open ocean or along narrow bays (Conant et al. 2009). Nesting beaches tend to be wide and sandy, backed by low dunes and fronted by a flat sandy approach from the water (Miller et al. 2003). Nests are typically laid between the high tide line and the dune front (Hailman and Elowson 1992). Within the north Pacific, loggerheads nest exclusively in Japan where a 50 to 90 percent decrease has been documented (Kamezaki et al. 2003). In the south Pacific, nesting beaches are restricted to eastern Australia and New Caledonia. Although the nesting trend in the north Pacific since 2001 has been on an upward trajectory (National Marine Fisheries Service 2008), these nesting populations continue to face impacts from directed hunting, coastal development, light pollution, beach armoring (Kamezaki et al. 2003), and incidental capture in coastal and pelagic fisheries (Peckham et al. 2007, Ishihara et al. 2011, Lewison et al. 2004). Beach erosion due to increased typhoon frequency and extreme temperatures are also known to cause high nest mortality.

Females lay three to five clutches of eggs, sometimes more, throughout a single nesting season (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007d). Clutch size is usually between 100 to 130 eggs (Dodd 1988). The temperature of a viable nest ranges between 26 and 32°C (79 and 90 degrees Fahrenheit). Eggs incubate for approximately 2 months before they hatch (Yntema and Mrosovsky 1980). An incubation temperature near the upper end of the viable range produces females, and an incubation temperature near the lower end produces male hatchlings (Yntema and Mrosovsky 1980).

3.5.2.6.3 Population and Abundance

The loggerhead sea turtle occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. However, the majority of loggerhead nesting is at the western rims of the Atlantic and Indian oceans (Encalada et al. 1998). South Florida and Masirah, Oman, are the only two nesting beaches in the world with greater than 10,000 females nesting per year. The total estimated nesting in the United States is approximately 68,000 to 90,000 nests per year. The major nesting concentrations in the United States are found in South Florida; however, loggerheads nest from Padre Island in South Texas to Virginia (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c). The only known nesting areas for loggerheads in the North Pacific are found in southern Japan (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c, Kamezaki et al. 2003).

Snover et al. (2010) combined nesting data from the Sea Turtle Association of Japan and data from Kamezaki et al. (2003) to analyze an 18-year time series of nesting data from 1990–2007. Nesting declined from an initial peak of approximately 6,638 nests in 1990–1991 to a low of 2,064 nests in 1997. During the past decade, nesting increased gradually to 5,167 nests in 2005, declined and then rose again to a high of just under 11,000 nests in 2008. While nesting numbers have gradually increased in recent years, historical evidence from Kamouda Beach, Japan (census data dates back to the 1950s) indicates that there has been a substantial decline over the last half of the 20th century (Kamezaki et al. 2003) and that current nesting represents a fraction of historical nesting levels.

There are no sighting, stranding, or nesting records for loggerhead turtles around Guam and the Commonwealth of the Northern Mariana Islands. As a result, loggerhead turtles are considered rare within the MITT Study Area. The nearest occurrences of this species are from the waters off Palau and the Philippines (Sagun et al. 2005). This species is more apt to be found in temperate waters of the North Pacific Ocean (i.e., north of 25°N) off of countries such as Japan, China, Taiwan, northwestern Mexico, and the southwestern U.S. including Hawaii (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c; Polovina et al. 2001, 2004). However, Guam and the Commonwealth of the Northern Mariana Islands are identified as being within the species' overall range (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007d, Kobayashi et al. 2008). Also, the westward flowing current of the North Pacific Subtropical Gyre system, which late juvenile stage loggerheads use when returning to the western Pacific, passes through the Marianas region (Polovina et al. 2000). Given the paucity of animal sightings, for modeling purposes in the effects analysis that follows, a density of 0.000022 animals per km^2 (1 sea turtle per 45,454 km^2 [17,550 $mi.^2$]) is used to represent the occasional transit of the MITT Study Area (U.S. Department of the Navy 2012).

3.5.2.6.4 Predator-Prey Interactions

In both open ocean and nearshore habitats, loggerheads are primarily carnivorous, although they also consume some algal matter (Parker et al. 2005; Bjorndal 1997; Dodd 1988). The gut contents of post-hatchlings found in masses of Sargassum contained parts of Sargassum, zooplankton, jellyfish, larval shrimp and crabs, and gastropods (Carr and Meylan 1980; Richardson and McGillivary 1991; Witherington 1994). Both juveniles and adults forage in coastal habitats, where they feed primarily on the bottom, although they also capture prey throughout the water column (McClellan et al. 2010, Bjorndal 2003). Adult loggerheads feed on a variety of bottom-dwelling animals, such as crabs, shrimp, sea urchins, sponges, and fish. They have powerful jaws that enable them to feed on hard-shelled prey, such as whelks and conch. During migration through the open sea, they eat jellyfish, mollusks, flying fish, and squid.

Depredation of sea turtle eggs and hatchlings by native and introduced species occurs on almost all nesting beaches. Land predators that feed on eggs and hatchlings include crabs, insects, and mammals, such as feral/domestic dogs, foxes, and feral pigs. Aquatic predators, mostly fish and sharks, impact hatchlings most heavily in nearshore areas. Sharks are also the primary predators of juvenile and adult turtles (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998e).

3.5.2.6.5 Species-Specific Threats

In addition to the general threats described in the introduction to this resource, mortality associated with shrimp trawls in the Atlantic has been a substantial threat to juvenile loggerheads because these trawls operate in the nearshore habitats commonly used by this species. Although shrimping nets have been modified with turtle excluder devices to allow sea turtles to escape, the overall effectiveness of these devices has been difficult to assess (National Marine Fisheries Service and U.S. Fish and Wildlife 2009). Shrimp trawl fisheries account for the highest number of loggerhead sea turtle fishery mortalities; they are also captured and killed in trawls, traps and pots, longlines, and dredges.

3.5.2.6.6 Olive Ridley Sea Turtle (*Lepidochelys olivacea*)

3.5.2.6.7 Status and Management

Olive ridleys are classified as threatened under the ESA, although the Mexican Pacific coast nesting population is listed as endangered. Critical habitat has not been designated for the olive ridley.

3.5.2.6.8 Habitat and Geographic Range

The olive ridley is known as an open ocean species, but can be found in coastal areas. They are found in tropical waters of the south Atlantic, Indian, and Pacific Oceans.

3.5.2.6.8.1 Open Ocean

Most olive ridley turtles lead a primarily open ocean life (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f). Outside of the breeding season, the turtles disperse, neither males nor females migrate to one specific foraging area, and the olive ridleys tend to roam and occupy a series of feeding areas in the open ocean (Plotkin et al. 1994, Plotkin 2010, Whiting 2007). The olive ridley has a large range in tropical and subtropical regions in the Pacific Ocean, and is generally found between 40°N and 40°S. Both adult and juvenile olive ridley turtles typically inhabit offshore waters, foraging from the surface to a depth of 490 ft. (149.4 m) (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f).

Little is known about the age and sex distribution, growth, birth and death rates, or immigration and emigration of olive ridley turtles. Hatchling survivorship is unknown, although presumably, as with other turtles, many die during the early life stages. Both adults and juveniles occur in open sea habitats, often seen on at-sea transect studies (Eguchi et al. 2007). The median age to sexual maturity is 13 years, with a range of 10 to 18 years (Zug et al. 2006).

3.5.2.6.8.2 Coastal

Olive ridley turtles use two types of nesting strategies (Jensen et al. 2006). One strategy is to perform synchronized nesting, a phenomenon known as an arribada (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f), where hundreds to tens of thousands of olive ridley turtles emerge over a period of a few days. In the eastern Pacific Ocean, arribada nesting occurs throughout the year, although it peaks from August to November (Fonseca et al. 2009, Valverde 2012). Arribadas occur on several beaches in Mexico, Nicaragua, Costa Rica, and Panama. Olive ridley turtles also lay solitary nests throughout the world, although little attention has been given to this nesting strategy because of the dominant interest in arribada research (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b). Nesting occurs in at least 60 countries throughout the world (Abreu-Grobois and Plotkin 2008), including along nearly the entire Pacific Ocean coast of Mexico, with the greatest concentrations closer to arribada beaches.

Females and males begin to group in “reproductive patches” near their nesting beaches 2 months before the nesting season, and most mate near the nesting beaches, although mating has been observed throughout the year as far as 565 mi. (909.3 km) from the nearest mainland (Pitman 1990). Arribadas usually last from 3 to 7 nights, and due to the sheer number of nesters, later arrivers disturb and dig up many existing nests, lowering overall survivorship during this phase (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f). A typical female produces, on average, two clutches per nesting season, averaging 100–110 eggs at 14-day intervals for lone nesters and 28-day intervals for mass nesters (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007, Plotkin et al. 1994). Studies show that females that are part of arribadas remain within 3 mi. (4.8 km) of the beach most of the time during the internesting period (Kalb and Owens 1994). Incubation time from egg deposition to hatching is approximately 55 days (Pritchard and Plotkin 1995). Hatchlings emerge weighing less than 1 oz. (less than 28 g) and measuring about 1.5 in. (3.8 cm).

3.5.2.6.9 Population and Abundance

There has been a general decline in the abundance of this species since its listing in 1978. Even though there are no current estimates of worldwide abundance, the olive ridley is still considered the most abundant of the world’s sea turtles (Pritchard 1997) and the most abundant sea turtle in the open ocean waters of the eastern tropical Pacific Ocean (Pitman 1990). However, the number of olive ridley turtles occurring in U.S. territorial waters is believed to be small (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f). Before the commercial exploitation of olive ridley turtles, this species was highly abundant in the eastern tropical Pacific Ocean, probably outnumbering all other sea turtle species combined in the area (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f).

Available information indicates that the population could be separated by ocean basins under the distinct population segment policy (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998e). 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 (Bowen and Karl 1997, Shankar et al. 2004).

The olive ridley nests in nearly 60 countries worldwide, in some locations with an estimated 800,000 females nesting annually Valverde et al. 2012). This is a dramatic decrease over the past 50 years, where the population from the five Mexican Pacific Ocean beaches was previously estimated at 10 million adults (Cliffton et al. 1995). Similarly, the largest nesting aggregation in the world used to occur in the Indian Ocean along the northeast coast of India (Orissa), where in 1991 over 600,000 turtles (from two separate arribadas) nested in a single week (Nmosovsky 2001; Shanker et al. 2004) and typical reported estimates have ranged from 100 to 800,000 nesting turtles (Shanker et al. 2004). Over the past 5 years at Gahirmatha (one of the Indian nesting sites), there has been an arribada nesting event in only 2 of those 5 years. Additionally, between 1996 and 2002, the average size of nesting females declined at that site, indicative of a declining population (National Oceanic and Atmospheric Administration 2011).

Between 2006 and 2010, at a mass-nesting site in Costa Rica, arribadas ranged between 3,564 and 476,550 egg-laying females. However, when compared with historical data, the population appears to have declined (Valverde et al. 2012).

Only one olive ridley record exists for Guam and the Commonwealth of the Northern Mariana Islands, an alleged capture in the waters near Saipan. The exact location of this capture, however, is unknown since the turtle was offered for sale in a local souvenir shop. The nearest in-water sightings of this species have occurred within the Yap Districts (Eckert et al. 1999; Pritchard and Plotkin 1995). It is possible that future occurrences could occur in the MITT Study Area and vicinity as olive ridleys have been satellite-tracked through North Pacific waters as far south as 8°N during developmental migrations (Eguchi et al. 2007; Polovina et al. 2004). The occurrence of the olive ridley turtle is rare throughout the year in all waters surrounding Guam and the Commonwealth of the Northern Mariana Islands that are seaward of the shelf break because they are primarily an oceanic species. In portions of the MITT Study Area located inside the shelf break (e.g., Apra Harbor, Agat Bay, nearshore waters around northern Tinian), olive ridley turtle sightings would be rare. Given the paucity of sightings of olive ridleys, for modeling purposes in the effects analysis that follows, a density of 0.000001 animal per km^2 is used to represent the occasional transit of the MITT Study Area by an olive ridley sea turtle (U.S. Department of the Navy 2012).

3.5.2.6.10 Predator-Prey Interactions

Olive ridley turtles are primarily carnivorous. They consume a variety of prey in the water column and on the seafloor, including snails, clams, tunicates, fish, fish eggs, crabs, oysters, sea urchins, shrimp, and jellyfish (Fritts 1981; Márquez M. 1990; Mortimer 1995; Polovina et al. 2004).

Predators contribute to egg loss and include coyotes, opossums, raccoons, feral dogs and pigs, and humans. The predators of hatchlings on the beach include crabs, snakes, iguanas, frigatebirds, vultures, coyotes, and raccoons; in the water they include predatory fish. As with all marine turtles, sharks are likely to be major predators of all age classes at sea (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f).

3.5.2.6.11 Species-Specific Threats

The principal cause of the historical, worldwide decline of the olive ridley sea turtle is long-term collection of eggs and killing of adults on nesting beaches (Abreu-Grobis and Plotkin 2008). Because arribadas concentrate females and nests in time and space, they allow for mass killing of adult females as well as the taking of an extraordinary number of eggs. These threats continue in some areas of the world today, compromising efforts to recover this species (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b), though some regions are employing legal harvests as a management tool (Valverde et al. 2012).

3.5.2.7 Leatherback Sea Turtle (*Dermochelys coriacea*)

3.5.2.7.1 Status and Management

The leatherback turtle is listed as a single population, and is classified as endangered under the ESA.

In January 2012, NMFS designated critical habitat in the Pacific Ocean along California (from Point Arena to Point Arguello, east of the 3,000 m [9,842.5 ft.] depth contour) and Washington and Oregon (from Cape Flattery, Washington, to Cape Blanco, Oregon, east of the 2,000 m [6,561.7 ft.] depth contour)

(77 Federal Register 170-4201). There is no critical habitat designated for the leatherback sea turtle in the MITT Study Area.

3.5.2.7.2 Habitat and Geographic Range

The leatherback turtle is the most widely distributed of all sea turtles, found from tropical to subpolar oceans, and nests on tropical and occasionally subtropical beaches (Myers and Hays 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992). Found from 71°N to 47°S, it has the most extensive range of any adult turtle (Eckert et al. 2012). Leatherbacks are also the most migratory sea turtles and are able to tolerate colder water (thermoregulatory adaptations such as a counter-current heat exchange system, high oil content, and large body size allow them to maintain a core body temperature higher than that of the surrounding water) than other species (Hughes et al. 1998; James and Mrosovsky 2004).

3.5.2.7.2.1 Open Ocean

Adult leatherback turtles forage in temperate and subpolar regions in all oceans, and migrate to tropical nesting beaches between 30°N and 20°S. Hatchling leatherbacks head out to the open ocean, but little is known about their distribution for the first 4 years (Musick and Limpus 1997). Sightings of turtles smaller than 55 in. (139.7 cm) indicate that some juveniles remain in coastal waters in some areas (Eckert 2002).

As with other sea turtle species, limited information is available on the open ocean habitats used by hatchling and early juvenile leatherbacks (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992). Other than a general association with warm waters, little is known of the distribution of hatchling and early juvenile leatherbacks, although Eckert (2002) noted a gradual increase in turtle size with increasing latitude. Upwelling areas, such as equatorial convergence zones, are nursery grounds for hatchling and early juvenile leatherbacks, because these areas provide a good supply of prey (Musick and Limpus 1997).

3.5.2.7.2.2 Coastal

Throughout their lives, leatherbacks are essentially oceanic, yet they enter coastal waters to forage and reproduce (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992). The species is not typically associated with coral reefs, but is occasionally encountered in deep ocean waters near prominent island chains (Eckert 1993). There is evidence that leatherbacks are associated with oceanic front systems, which occur frequently along shelf breaks and the edges of oceanic gyre systems, and is often where their prey (mainly planktonic) is concentrated (Benson et al. 2011, Eckert 1993).

Leatherbacks have a wide nesting distribution, primarily on isolated mainland beaches in tropical oceans (mainly in the Atlantic and Pacific Oceans, with few in the Indian Ocean) and temperate oceans (southwest Indian Ocean) (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992), and to a lesser degree on some islands. Nesting leatherbacks prefer wide sandy beaches backed with vegetation (Eckert 1987; Hirth and Ogren 1987). For both the western and eastern Pacific Ocean populations, the nesting season extends from October through March, with a peak in December. The single exception is the Jamursba-Medi (Papua) stock, which nests from April to October, with a peak in August (Chaloupka et al. 2004). Typical clutches are 50 to more than 150 eggs, with the incubation period lasting around 65 days. Females lay an average of five to seven clutches in a single season (with a maximum of 11) with intervals of 8 to 10 days or longer (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992). Females remain in the general vicinity of the nesting habitat for their breeding period, which can last up to 4 months (Eckert, K. et al. 1989; Eckert S. et al. 1989; Keinath and Musick 1993), although they may nest on several islands in a chain during a single nesting season

(Pritchard 1982). Mating is thought to occur before or during the migration from temperate to tropical waters (Eckert and Eckert 1988).

3.5.2.7.3 Population and Abundance

Most stocks in the Pacific Ocean are faring poorly, where nesting populations have declined more than 80 percent since 1982 (Sarti-Martinez 2000), while western Atlantic and South African populations are generally stable or increasing (Turtle Expert Working Group 2007). Worldwide, the largest nesting populations now occur off of Gabon in equatorial West Africa (5,865 to 20,499 females nesting per year [Witt et al. 2009]), in the western Atlantic in French Guiana (4,500 to 7,500 females nesting per year [Dutton et al. 2007]) and Trinidad (estimated 6,000 turtles nesting annually [Eckert 2002]), and in the western Pacific in West Papua (formerly Irian Jaya), Indonesia (about 600 to 650 females nesting per year [Dutton et al. 2007]). By 2004, 203 nesting beaches from 46 countries around the world had been identified (Dutton 2006). Of these, 89 sites (44 percent) have generated data from beach monitoring programs. Although these data are beginning to form a global perspective, unidentified sites likely exist, and incomplete or no data are available for many known sites. Genetic studies have been used to identify two discrete leatherback populations in the Pacific Ocean (Dutton 2006): an eastern Pacific Ocean population, which nests between Mexico and Ecuador; and a western Pacific Ocean population, which nests in numerous countries, including Indonesia, Papua New Guinea, Solomon Islands, and Vanuatu. There are 28 known nesting sites for the western Pacific Ocean stock, with 5,000 to 9,100 leatherback nests laid annually across the western tropical Pacific Ocean, from Australia and Melanesia (Papua New Guinea, Solomon Islands, Fiji, and Vanuatu) to Indonesia, Thailand, and China (Chaloupka et al. 2004; Dutton 2006; Hirth et al. 1993; Hitipeuw et al. 2007; Suarez et al. 2000). Although, no more than 10 nests are estimated to be laid annually in Malaysia (Eckert et al. 2012) and only approximately 20 to 30 nests are laid in Fiji (Rupeni et al. 2002).

Leatherbacks have been in decline in all major Pacific basin rookeries (nesting areas/groups) (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b, Turtle Expert Working Group 2007) for at least the last two decades (Sarti-Martinez et al. 1996, Spotila et al. 1996, Spotila et al. 2000). Causes for this decline include the nearly complete harvest of eggs and high levels of mortality during the 1980s, primarily in the high seas driftnet fishery, which is now banned (Chaloupka et al. 2004, Eckert and Sarti-Martinez 1997, Sarti-Martinez et al. 1996).

Of the three sea turtle species that have been sighted around Guam and the Commonwealth of the Northern Mariana Islands during marine surveys, the leatherback turtle is the least common (U.S. Department of the Navy 2003b). This species is occasionally encountered in the deep, pelagic waters of the Marianas archipelago, although only a few occurrence records exist (Eckert et al. 1999). Recent National Oceanic and Atmospheric Administration satellite tracking of leatherback turtles departing from regional nesting habitats transit through MITT waters (Benson et al. 2011; Benson et al. 2007; Kobayashi et al. 2008). As for nearshore waters, Eldredge (2003) noted a rescue in 1978 of a 249-pound (lb.) (112.9 kg) leatherback from waters southeast of Cocos Island, Guam. From 1987 to 1989, divers reported seeing leatherbacks in the waters off Harmon Point, Rota; however, none have been seen in the area in recent times (U.S. Department of the Navy 2010). Leatherbacks do not nest at any of the islands in Micronesia. As a result, the occurrence of leatherback turtles would be considered rare throughout the year in nearshore waters of the Study Area. Since leatherback occurrences in the waters off Guam and the Commonwealth of the Northern Mariana Islands would most likely involve individuals in transit, occurrence is not expected in coastal (i.e., shelf) waters around any of the islands in the Study Area. Given the paucity of animal sightings, for modeling purposes in the effects analysis that follows, a density of 0.000022 animal per km^2 is used to represent the occasional transit of the MITT Study Area (U.S. Department of the Navy 2012).

3.5.2.7.4 Predator-Prey Interactions

Leatherbacks lack the crushing and chewing plates characteristic of hard-shelled sea turtles that feed on hard-bodied prey (National Marine Fisheries Service 2010). Instead, they have pointed tooth-like cusps and sharp-edged jaws that are perfectly adapted for a diet of soft-bodied prey, such as jellyfish and salps (planktonic tunicate) (Bjorndal 1997; Grant and Ferrell 1993; James and Herman 2001; National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992; Salmon et al. 2004). Leatherbacks feed from the surface as well as at depth, potentially diving up to 4,035 ft. (1,230 m) (Eckert S. et al. 1989; Eisenberg and Frazier 1983; Grant and Ferrell 1993; Hays et al. 2004a; Hays 2004b; Hays et al. 2004c; James et al. 2005; Salmon et al. 2004). Leatherbacks in the Caribbean may synchronize their diving patterns with the daily vertical migration of a deep-water ecosystem of fishes, crustaceans, gelatinous salps, and siphonophores, known as the deep scattering layer, which moves toward the surface of the ocean at dusk and rapidly descends in the morning (Eckert et al. 1986; Eckert, K. et al. 1989; Eckert, S. et al. 1989). A similar vertical migration of small fish and crustacean species has been studied in the Pacific, which migrates from approximately 1,300 to 2,300 ft. (396 to 701 m) during the day to near the surface at night (Benoit-Bird et al. 2001). Researchers studying known feeding grounds have observed leatherbacks foraging on jellyfish at the surface (Grant and Ferrell 1993; James and Herman 2001).

Predators contribute to egg loss and include feral pigs and dogs, crickets, raccoons and armadillos, lizards, crabs, ants, among others (Tapilatu and Tiwari 2007). Predation of hatchlings is commonly observed in birds and fish. As with all marine turtles, sharks are likely to be major predators of all age classes at sea, and killer whales predate leatherback adults (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998d).

3.5.2.7.5 Species-Specific Threats

In addition to the general threats described at the beginning of Section 3.5.2 (Affected Environment), harvest of leatherback sea turtle eggs and adult turtles continues to be a threat in many parts of the world. Additionally, incidental capture in longline and coastal gillnet fisheries has caused a substantial number of leatherback sea turtle deaths, likely because leatherback sea turtles dive to depths targeted by fishermen and are less maneuverable than other sea turtle species (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007c).Mortality was observed most commonly occurring from incidental capture in driftnets, rather than from longlines (Alfaro-Shigueto et al. 2011). Further, because leatherback sea turtles distribution is so closely associated jellyfish aggregations, any changes in jellyfish distribution or abundance may be a threat to this species.

3.5.3 ENVIRONMENTAL CONSEQUENCES

This section presents the analysis of potential impacts on sea turtles from implementation of the project alternatives, including the No Action Alternative, Alternative 1, and Alternative 2. Each sea turtle substressor is introduced, analyzed by alternative, and analyzed for training activities and testing activities, and then an ESA determination is made by substressor. The stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors applicable to sea turtles in the MITT Study Area and analyzed below include the following:

- Acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise)

- Energy (electromagnetic devices)
- Physical disturbance and strike (vessels and in-water devices, military expended materials, and seafloor devices)
- Entanglement (fiber optic cables and guidance wires, and decelerators/parachutes)
- Ingestion (munitions and military expended materials other than munitions)
- Secondary (impacts associated with sediments and water quality)

The specific analysis of the training and testing activities presented in this section considers the relevant components and associated data within the geographic location of the activity (see Tables 2.8-1 through 2.8-4) and the resource.

3.5.3.1 Acoustic Stressors

3.5.3.1.1 Impulse and Non-Impulse Sound Sources

Assessing whether sounds may disturb or injure an animal involves understanding the characteristics of the acoustic sources, the animals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those animals.

The methods used to predict acoustic effects on sea turtles build upon the Conceptual Framework for Assessing Effects from Sound-Producing Activities (Appendix H, Biological Resource Methods). Additional research specific to sea turtles is presented where available.

3.5.3.1.2 Analysis Background and Framework

A range of impacts on sea turtles could occur depending on the sound source. The impacts of exposure to non-explosive, sound-producing activities or to sounds produced by an explosive detonation could include permanent or temporary hearing loss, changes in behavior, and physiological stress. In addition, potential impacts from an explosive impulse can range from physical discomfort to non-lethal and lethal injuries. Immediate non-lethal injury includes slight injury to internal organs and injury to the auditory system, which could reduce long-term fitness (lifetime reproductive success). Immediate lethal injury would be a result of massive combined trauma to internal organs as a direct result of proximity to the point of detonation.

3.5.3.1.2.1 Direct Injury

Direct injury from non-impulsive sound sources, such as sonar, is unlikely due to relatively lower peak pressures and slower rise times than potentially injurious sources such as explosives. Non-impulsive sources also lack the strong shock waves that are associated with explosives. Therefore, primary blast injury and barotrauma would not occur due to exposure to non-impulsive sources such as sonar and are only considered for explosive detonations.

The potential for trauma in sea turtles exposed to impulsive sources (e.g., explosions) has been inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Ketten et al. 1993; Richmond et al. 1973; Yelverton et al. 1973). The effects of an underwater explosion on a sea turtle are dependent upon multiple factors, including size, type, and depth of both the animal and the explosive, depth of the water column, and distance from the charge to the animal. Smaller sea turtles would generally be more susceptible to injury. The compression of blast-sensitive, gas-containing organs when a sea turtle increases depth reduces likelihood of injury to these organs. The location of the explosion in the water column and the underwater environment determines whether most energy is released into the water or the air and influences the propagation of the blast wave.

Primary Blast Injury and Barotrauma

The greatest potential for direct, non-auditory tissue impacts is primary blast injury and barotrauma after exposure to the shock waves of high-amplitude impulse sources, such as explosions. Primary blast injury refers to those injuries that result from the initial compression of a body exposed to the high pressure of a blast or shock wave. Primary blast injury is usually limited to gas-containing structures (e.g., lung and gut) and the pressure-sensitive components of the auditory system (discussed below) (Stuhmiller et al. 1991; Craig and Hearn 1998; Craig Jr. 2001), although additional injuries could include concussive brain damage and cranial, skeletal, or shell fractures (Ketten 1995). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system, as measured in terrestrial mammals, may consist of lung bruising, collapsed lung, traumatic lung cysts, or air in the chest cavity or other tissues (Stuhmiller et al. 1991). These injuries may be fatal depending on the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air blockage that can cause a stroke or heart attack by restricting oxygen delivery to these organs. Although often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer bruising and tearing from blast exposure, particularly in air-containing regions of the tract. Potential traumas include internal bleeding, bowel perforation, tissue tears, and ruptures of the hollow abdominal organs. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered. Non-lethal injuries could increase a sea turtle's risk of predation, disease, or infection.

Auditory Trauma

Components of the auditory system that detect smaller or more gradual pressure changes can also be damaged when overloaded at high pressures with rapid rise times. Rupture of the eardrum, while not necessarily a serious or life-threatening injury, may lead to permanent hearing loss (Ketten 1995, 1998). No data exist to correlate the sensitivity of the sea turtle tympanum and middle and inner ear to trauma from shock waves associated with underwater explosions (Viada et al. 2008).

The specific impacts of bulk cavitation on sea turtles are unknown (see Costanzo 2010, for an explanation of cavitation following an explosive detonation). The presence of a sea turtle within the cavitation region created by the detonation of small charges could annoy, injure, or increase the severity of the injuries caused by the shock wave, including injuries to the auditory system or lungs. Presence within the area of cavitation from a large charge, such as those used in ship shock trials, is expected to be an area of almost complete total physical trauma (Craig and Rye 2008). An animal located at (or in the immediate vicinity of) the cavitation closure depth would be subjected to a short duration ("water hammer") pressure pulse; however, direct shock wave impacts alone would be expected to cause auditory system injuries and could cause internal organ injuries.

3.5.3.1.2.2 Hearing Loss

Hearing loss could effectively reduce the distance over which sea turtles can detect biologically relevant sounds. Both auditory trauma (a direct injury discussed above) and auditory fatigue may result in hearing loss, but the mechanisms responsible for auditory fatigue differ from auditory trauma. Hearing loss due to auditory fatigue is also known as threshold shift, a reduction in hearing sensitivity at certain frequencies. Threshold shift is the difference between hearing thresholds measured before and after an intense, fatiguing sound exposure. Threshold shift occurs when hair cells in the ear fatigue, causing them to become less sensitive over a small range of frequencies related to the sound source to which an animal was exposed. Hair cells are part of the basilar membrane and are responsible for converting the mechanical movement of waves of sound to an electrochemical signal that is received by the auditory nerve. Each hair cell has a characteristic frequency that is correlated with its position along the basilar membrane. The actual amount of threshold shift depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure. No studies are published on inducing threshold shift in sea turtles; therefore, the potential for the impact on sea turtles is inferred from studies of threshold shift in other animals.

Temporary threshold shift (TTS) is a hearing loss that recovers to the original hearing threshold over a period of time. An animal may not even be aware of a TTS. It does not become deaf, but requires a louder sound stimulus (relative to the amount of TTS) to detect a sound within the affected frequencies. TTS may last several minutes to several days, depending on the intensity and duration of the sound exposure that induced the threshold shift (including multiple exposures).

Permanent threshold shift (PTS) is a permanent loss of hearing sensitivity at a certain frequency range. PTS is non-recoverable due to the destruction of tissues within the auditory system. The animal does not become deaf, but requires a louder sound stimulus (relative to the amount of PTS) to detect a sound within the affected frequencies. As the name suggests, the effect is permanent.

3.5.3.1.2.3 Auditory Masking

Auditory masking occurs when a sound prevents or limits the distance over which an animal detects other biologically relevant sounds. When a sound has a level above the sound of interest, and in a similar frequency band, auditory masking could occur (Appendix H, Biological Resource Methods). Any sound above ambient noise levels and within an animal's hearing range may potentially cause masking. The degree of masking increases with increasing noise levels; a noise that is just-detectable over ambient levels is unlikely to actually cause any substantial masking, whereas a louder noise may mask sounds over a wider frequency range. In addition, a continuous sound would have more potential for masking than a sound with a low duty cycle. In the open ocean, ambient noise levels are between about 60 and 80 dB re 1 µPa, especially at lower frequencies (below 100 Hz) and nearshore, ambient noise levels, especially around busy ports, can exceed 120 dB re 1 µPa (Urick 1983).

Unlike auditory fatigue, which always results in a localized stress response, behavioral changes resulting from auditory masking may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone.

Based on knowledge of sea turtle sensory biology (Martin et al. 2012, Crognale et al. 2008, Southwood et al. 2008, Bartol and Ketten 2006, Bartol and Musick 2003, Levenson et al. 2004), sea turtles may be able to detect objects within the water column (e.g., vessels, prey, predators) via some combination of auditory, visual or chemical cues. However, research examining the ability of sea turtles to avoid collisions with vessels and to avoid fishing gear (Southwood et al. 2008, Hazel et al. 2007) indicate that visual cues dominate over auditory, olfactory, and probably gustatory cues as well. Similarly, while sea turtles may rely somewhat on acoustic cues to identify nesting beaches, they appear to rely more heavily on other non-acoustic cues for navigation, such as magnetic fields (Lohmann 1991; Lohmann and Lohmann 1996a, b) and light (Avens and Lohmann 2003). Additionally, they are not known to produce sounds underwater for communication, navigation, or foraging. As a result, sound likely plays a limited role in a sea turtle's environment. It is unknown what role sound plays in a sea turtle environment; therefore, the potential for masking may be limited.

3.5.3.1.2.4 Physiological Stress

Sea turtles may exhibit a behavioral response or combinations of behavioral responses upon exposure to anthropogenic sounds. If a sound is detected, a stress response (i.e., startle or annoyance) or a cueing response (based on a past stressful experience) can occur. Sea turtles 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 activities have the potential to provide additional stressors above and beyond those that occur in the absence of human activity.

Immature Kemp's ridley sea turtles show physiological responses to the acute stress of capture and handling through increased levels of the stress hormone corticosterone, along with biting and rapid flipper movement (Gregory and Schmid 2001). Kemp's ridley sea turtles are not found in the Study Area; however, they are closely related to olive ridley sea turtles, which are found in the Study Area. Studies involving Kemp's ridley sea turtles are applicable to olive ridleys when comparative studies for olive ridley sea turtles are lacking. Captive olive ridley hatchlings showed heightened blood glucose levels following retention in holding ponds, indicating physiological stress (Rees et al. 2008; Zenteno et al. 2008). Repeated exposure to stressors, including human disturbance such as vessel disturbance and anthropogenic sound, may result in negative consequences to the health and viability of an individual or population (Gregory and Schmid 2001). Factors to consider when predicting a stress or cueing response is whether an animal is naïve or has prior experience with a stressor. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation.

3.5.3.1.2.5 Behavioral Reactions

The response of a sea turtle to an anthropogenic sound will 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 source and whether it is perceived as approaching or moving away could also affect the way a sea turtle responds to a sound. Potential behavioral responses to anthropogenic sound could include startle reactions, disruption of feeding, disruption of migration, changes in respiration, alteration of swim speed, alteration of swim direction, area avoidance, and disruption of mating or reproduction (nesting).

There are limited studies of sea turtle responses to sounds. No studies have been performed to examine the response of sea turtles to sonar. However, based on their limited range of hearing, they may respond to sources operating below 2 kilohertz (kHz) but are unlikely to sense higher frequency sounds. A few studies examined sea turtle reactions to airguns, which produce broadband impulse sound. O'Hara and Wilcox (1990) attempted to create a sound barrier at the end of a canal using seismic airguns. They reported that loggerhead turtles kept in a 984 ft. x 148 ft. (300 m x 45 m) enclosure in a 10 m (32.8 ft.) deep canal maintained a standoff range of 98 ft. (30 m) from airguns fired simultaneously at intervals of 15 seconds with strongest sound components within the 25–1,000 Hz frequency range. More frequent airgun blasts did not produce behavior different from that observed at lower frequencies. Also, reverberation of acoustic stimuli off of canal walls confound observations as well as experimental conditions. McCauley et al. (2000) estimated that the received level at which turtles avoided sound in the O'Hara and Wilcox (1990) experiment was 175 to 176 dB re 1 µPa root mean square (rms).

Moein Bartol et al. (1995) investigated the use of air guns to repel juvenile loggerhead sea turtles from hopper dredges. Sound frequencies of the airguns ranged from 100 to 1,000 Hz at three levels: 175, 177, and 179 dB re 1 µPa at 1 m. The turtles avoided the airguns during the initial exposures (mean range of 24 m), but additional trials several days afterward did not elicit statistically significant avoidance. They concluded that this was due to either habituation or a temporary shift in the turtles' hearing capability. In a related study, Lenhart (1994) found no consistent response to a fixed sound source in net or tank studies with juvenile loggerheads.

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

No obvious avoidance reactions by free-ranging sea turtles, such as swimming away, were observed during a multi-month seismic survey using airgun arrays, although fewer sea turtles were observed when the seismic airguns were active than when they were inactive (Weir 2007). The author noted that sea state and the time of day affected both airgun operations and sea turtle surface basking behavior, making it difficult to draw conclusions from the data. DeRuiter and Doukara (2012) noted that 49 of 86 loggerhead turtles basking at the sea surface dove in response to airgun sound exposure, the majority of turtles observed while at the surface dove at or before their closest point of approach to the airgun array blasts, and that dive probability decreased with increasing distance from the airgun array.

3.5.3.1.2.6 Repeated Exposures

Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with energetic costs that can accumulate over time to cause long-term negative consequences for the individual. Conversely, some sea turtles may habituate to or become tolerant of repeated exposures over time, learning to ignore a stimulus that in the past did not accompany any overt threat, such as high levels of ambient noise found in areas of high vessel traffic (Hazel et al. 2007). In an experiment, after initial avoidance reactions, loggerhead sea turtles habituated to repeated exposures to airguns of up to a source level of 179 dB re 1 µPa in an enclosure. The habituation behavior was retained by the sea turtles when exposures were separated by several days (Moein Bartol et al. 1995).

3.5.3.1.3 Acoustic and Explosive Thresholds and Criteria

Animals generally do not hear equally well across their entire hearing range. Several studies using green, loggerhead, and Kemp's ridley turtles suggest sea turtles are most sensitive to low-frequency sounds, although this sensitivity varies slightly by species and age class (Bartol and Ketten 2006; Bartol et al. 1999; Lenhardt 1994; Ridgway et al. 1969). Sea turtles possess an overall hearing range between 100 Hz and 1 kHz, with an upper limit of 2 kHz (Bartol and Ketten 2006; Bartol et al. 1999; Lenhardt 1994; Ridgway et al. 1969).

Because hearing thresholds are frequency-dependent, an auditory weighting function can be derived for sea turtles (turtle-weighting, or T-weighting). The T-weighting function (Figure 3.5-1) defines lower and upper frequency boundaries beyond which sea turtle hearing sensitivity decreases. The single frequency cutoffs at each end of the frequency range where hearing sensitivity begins to decrease are based on the most liberal interpretations of sea turtle hearing abilities (10 Hz and 2 kHz). These boundaries are precautionary and exceed the demonstrated or anatomy-based hypothetical upper and lower limits of sea turtle hearing. Figure 3.5-1 shows the sea turtle auditory weighting function with lower and upper boundaries of 10 Hz and 2 kHz, respectively.

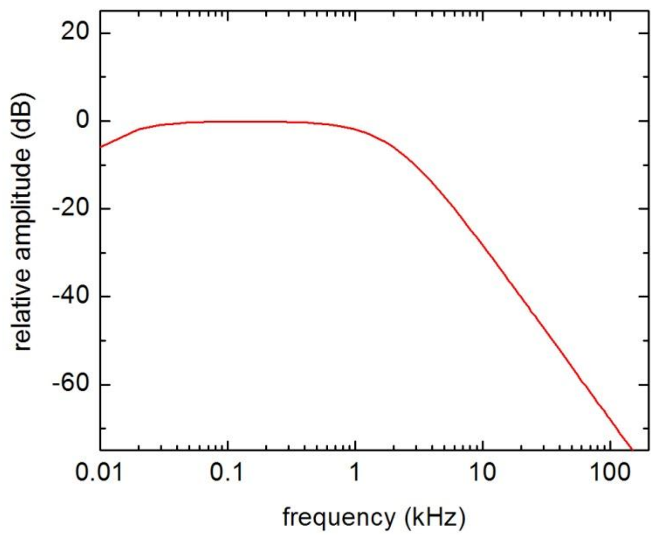

Figure 3.5-1: Auditory Weighting Function for Sea Turtles (T-Weighting)

The T-weighting function adjusts the received sound level based on sensitivity to different frequencies, emphasizing frequencies to which sea turtles are most sensitive and reducing emphasis on frequencies outside of their estimated useful range of hearing. For example, a 160 dB re 1 µPa tone at 10 kHz is estimated to be perceived by a sea turtle as a 130 dB re 1 µPa sound (i.e., 30 dB lower). Stated another way, a sound outside of the range of best hearing would have to be more intense to have the same impact as a sound within the range of best hearing. Weighting functions are further explained in Section 3.0.4 (Acoustic and Explosives Primer).

The Navy considers two primary categories of sound sources in its analyses of sound impacts on sea turtles: impulse sources (e.g., explosives, airguns, and weapons firing) and non-impulse sources (e.g., sonars, pingers, and countermeasure devices). General definitions of impulse and non-impulse sound sources are provided below. Acoustic impacts criteria and thresholds were developed in cooperation with the NMFS for sea turtle exposures to various sound sources. These acoustic impacts criteria are summarized in Table 3.5-2, Table 3.5-3, and Table 3.5-4. These criteria can be used to estimate the number of sea turtles impacted by training and testing activities that emit sound or explosive energy, as well as the severity of the immediate impacts. These criteria are used to quantify impacts from explosives, airguns, sonar, and other active acoustic sources. These criteria are also useful for qualitatively assessing activities that indirectly impart sound to water, such as firing of weapons and aircraft flights.

Table 3.5-2: Sea Turtle Impact Threshold Criteria for Non-Impulse Sources

Onset PTS	Onset TTS
198 dB SEL (T)	178 dB SEL (T)

Notes: (T) = Turtle Weighting Function, dB = decibels, PTS = Permanent Threshold Shift, TTS = Temporary Threshold Shift, SEL = Sound Exposure Level (the total acoustic energy in an event normalized to 1 second)

Table 3.5-3: Sea Turtle Impact Threshold Criteria for Impulse Sources

Impulse Sound Exposure Impact	Threshold Value
Onset Mortality (1 Percent Mortality Based on Extensive Lung Injury)	$= 91.4 M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-s$
Onset Slight Lung Injury	$= 39.1 M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-s$
Onset Slight Gastrointestinal Tract Injury	237 dB re 1 μPa SPL (104 psi)
Onset PTS	187 dB re 1 μPa^2-s SEL (T) or 230 dB re 1 μPa Peak SPL
Onset TTS	172 dB re 1 μPa^2-s SEL (T) or 224 dB re 1 μPa Peak SPL

Notes: μPa = micropascal, μPa^2-s = micropascal squared second, dB = decibels, D_{Rm} = depth of animal (meters), M = mass of animals (kilograms) as shown for each species in Table 3.5-4, PTS = Permanent Threshold Shift, re = referenced to, SEL = Sound Exposure Level, SPL = Sound Pressure Level, T= Turtle Weighting Function, TTS = Temporary Threshold Shift

Detailed description of the criteria and equations can be found in Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (U.S. Department of the Navy 2012b).

Table 3.5-4: Species-Specific Masses for Determining Onset of Extensive and Slight Lung Injury Thresholds

Common Name	Juvenile Mass (kg)	Reference
Loggerhead turtle	8.4	Southwood et al. (2007)
Green turtle	8.7	Wood and Wood (1993)
Hawksbill turtle	7.4	Okuyama et al. (2010)
Olive ridley turtle	6.3	McVey and Wibbels (1984) and Caillouet et al. (1986)[1]
Leatherback turtle	34.8	Jones (2009)

[1] McVey and Wibbels (1984) and Caillouet et al. (1986) measured masses for Kemp's ridley turtles, a closely related species to the olive ridley.

3.5.3.1.3.1 Categories of Sounds as Defined for Thresholds and Criteria

Categories of sound are discussed in Section 3.0.4 (Acoustic and Explosives Primer). Impulsive and non-impulsive are described again below with details specific to assigning acoustic and explosive criteria for predicting impacts on sea turtles.

3.5.3.1.3.2 Impulsive Sounds

Impulsive sounds (including explosions) have a steep pressure rise or rapid pressure oscillation, which is the primary reason the impacts of these sounds are considered separately from non-impulsive sounds. Impulsive sounds usually rapidly decay with only one or two peak oscillations and are of very short duration (usually 0.1 second or shorter). Rapid pressure changes may produce mechanical damage to the ear or other structures that would not occur with slower rise times found in non-impulsive signals. Impulse sources and sound analyzed in this document include explosives, airguns, sonic booms, and weapons firing.

3.5.3.1.3.3 Non-Impulsive Sounds

Non-impulsive sounds typically contain multiple pressure oscillations without a rapid rise time, although the total duration of the signal may still be quite short (0.1 second or shorter for some high frequency sources). Such sounds are typically characterized by a root mean square average sound pressure level or energy level over a specified period of time. Sonar and other active acoustic sources (e.g., pingers) are analyzed as non-impulsive sources in this document.

Intermittent non-impulsive sound sources produce sound for only a small fraction of the time that the source is in use (a few seconds or a fraction of a second, e.g., sonars and pingers), with longer silent periods in between the sound. Continuous sources are those that transmit sound for the majority of the time they are being used, often for many minutes, hours, or days. Vessel noise and aircraft noise are continuous noise sources analyzed in this document.

3.5.3.1.3.4 Criteria for Mortality and Injury from Explosives

There is a considerable body of laboratory data on actual injuries from impulse sounds, usually from explosive pulses, obtained from tests with a variety of vertebrate species (e.g., Goertner et al. 1994; Richmond et al. 1973; Yelverton et al. 1973). Based on these studies, potential impacts, with decreasing likelihood of serious injury or lethality, include onset of mortality, onset of slight lung injury, and onset of slight gastrointestinal injury.

In the absence of data specific to sea turtles, criteria developed to assess impacts on protected marine mammals are also used to assess impacts on protected sea turtles. These criteria are discussed below.

3.5.3.1.3.5 Criteria for Mortality and Slight Lung Injury

In air or submerged, the most commonly reported internal bodily injury due to explosive detonations is hemorrhaging in the fine structure of the lungs. The likelihood of internal bodily injury is related to the received impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973; Yelverton and Richmond 1981; Yelverton et al. 1973; Yelverton et al. 1975). Therefore, impulse is used as a metric upon which internal organ injury can be predicted. Onset mortality and onset slight lung injury are defined as the impulse level that would result in 1 percent mortality (most survivors have moderate blast injuries and should survive) and 0 percent mortality (recoverable, slight blast injuries) in the exposed population, respectively. Criteria for onset mortality and onset slight lung injury were developed using data from explosive impacts on mammals (Yelverton and Richmond 1981).

The impulse required to cause lung damage is related to the volume of the lungs. The lung volume is related to both the size (mass) of the animal and compression of gas-filled spaces at increasing water depth. Turtles have relatively low lung volume to body mass and a relatively stronger anatomical structure compared to mammals; therefore, application of the criteria derived from studies of impacts of explosives on mammals is conservative.

Table 3.5-4 provides a nominal conservative body mass for each sea turtle species based on juvenile mass. Juvenile body masses were selected for analysis given the early rapid growth of these reptiles (newborn turtles weigh less than 0.5 percent of maximum adult body mass). In addition, small turtles tend to remain at shallow depths in the surface pressure release zone, reducing potential exposure to injurious impulses. Therefore, use of hatchling weight would provide unrealistically low thresholds for estimating injury to sea turtles. The use of juvenile body mass rather than hatchling body mass was chosen to produce reasonably conservative estimates of injury.

The scaling of lung volume to depth is conducted for all species since data come from experiments with terrestrial animals held near the water's surface. The calculation of impulse thresholds consider depth of the animal to account for compression of gas-filled spaces that are most sensitive to impulse injury. The impulse required for a specific level of injury (impulse tolerance) is assumed to increase proportionally to the square root of the ratio of the combined atmospheric and hydrostatic pressures at a specific depth with the atmospheric pressure at the surface (Goertner 1982).

Very little information exists regarding the impacts of underwater detonations on sea turtles. Impacts on sea turtles from explosive removal operations range from non-injurious impacts (e.g., acoustic annoyance, mild tactile detection, or physical discomfort) to varying levels of injury (i.e., non-lethal and lethal injuries) (e.g., Klima et al. 1988; Viada et al. 2008). Often, impacts of explosive activities on turtles must be inferred from documented impacts on other vertebrates with lungs or other-gas containing organs, such as mammals and most fishes (Viada et al. 2008). The methods used by Goertner (1982) to develop lung injury criteria for marine mammals may not be directly applicable to sea turtles, as it is not known what degree of protection to internal organs from the shock waves is provided to sea turtles by their shell (Viada et al. 2008). However, the general principles of the Goertner model are applicable and should provide a protective approach to assessing potential impacts on sea turtles. The Goertner method predicts a minimum primary positive impulse value associated with onset of slight lung injury and onset of mortality, adjusted for assumed lung volume (correlated to animal mass) and depth of the animal. These equations are shown in Table 3.5-3.

3.5.3.1.3.6 Criteria for Onset of Gastrointestinal Tract Injury

Without data specific to sea turtles, data from tests with terrestrial animals are used to predict onset of gastrointestinal tract injury. It is shown that gas-containing internal organs, such as lungs and intestines, were the principle damage sites from shock waves in submerged terrestrial mammals (Clark and Ward 1943; Greaves et al. 1943; Richmond et al. 1973; Yelverton et al. 1973). Furthermore, slight injury to the gastrointestinal tract may be related to the magnitude of the peak shock wave pressure over the hydrostatic pressure and would be independent of the animal’s size and mass (Goertner 1982). Slight contusions to the gastrointestinal tract were reported during small charge tests (Richmond et al. 1973), when the peak was 237 dB re 1 µPa. Therefore, this value is used to predict onset of gastrointestinal tract injury in sea turtles exposed to explosions (see Table 3.5-3).

3.5.3.1.3.7 Criteria for Hearing Loss Temporary and Permanent Threshold Shift

Whereas TTS represents a temporary reduction of hearing sensitivity, PTS represents tissue damage that does not recover and permanent reduced sensitivity to sounds over specific frequency ranges (see Section 3.5.3.1.2.2, Hearing Loss). To date, no known data are available on potential hearing impairments (i.e., TTS and PTS) in sea turtles. Sea turtles, based on their auditory anatomy (Bartol and

Musick 2003a; Lenhardt et al. 1985; Wartzok and Ketten 1999; Wever 1978; Wyneken 2001), almost certainly have poorer absolute sensitivity (i.e., higher thresholds) across much of their hearing range than do the mid-frequency cetacean species. Therefore, applying TTS and PTS criteria derived from mid-frequency cetaceans to sea turtles should provide a protective approach to estimating acoustic impacts on sea turtles (PTS and TTS data are not available for low-frequency cetaceans). Criteria for hearing loss due to onset of TTS and PTS are based on sound exposure level (for non-impulse and impulse sources) and peak pressure (for impulse sources only).

To determine the sound exposure level, the turtle weighting function is applied to the acoustic exposure to emphasize only those frequencies within a sea turtle's hearing range. Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating the received sound exposure level for a given individual. This conservatively assumes no recovery of hearing between exposures during a 24-hour period. The weighted sound exposure level is then compared to weighted threshold values for TTS and PTS. If the weighted exposure level meets or exceeds the weighted threshold, then the physiological impact (TTS or PTS) is assumed to occur. For impacts from exposures to impulse sources, the metric (peak pressure or sound exposure level) and threshold level that results in the longest range to impact is used to predict impacts. Exposures are not calculated for sound sources with a nominal frequency outside the upper and lower frequency hearing limits for sea turtles.

In addition to being discussed below, thresholds for onset of TTS and PTS for impulse and non-impulse sounds are summarized in Table 3.5-2 and Table 3.5-3.

3.5.3.1.3.8 Criteria for Non-Impulsive Temporary Threshold Shift

Based on best available science regarding TTS in marine vertebrates (Finneran et al. 2002; Southall et al. 2007) and the lack of information regarding TTS in sea turtles, the total T-weighted sound exposure level of 178 dB re 1 micro Pascal squared second (μPa^2-s) is used to estimate exposures resulting in TTS for sea turtles. The T-weighting function is used in conjunction with this non-pulse criterion, which effectively provides an upper cutoff of 2 kHz.

The T-weighted non-impulsive TTS threshold of 178 dB re 1 μPa^2-s sound exposure level was inadvertently based on Type II weighted cetacean TTS data rather than Type I weighted cetacean TTS data. This resulted in incorrectly lowering the turtle TTS threshold by 17 dB. The sea turtle non-impulsive TTS threshold, based on mid-frequency cetacean data, should be 17 dB higher than 178 dB re 1 μPa^2-s. Because an incorrectly lowered threshold was used to quantitatively analyze acoustic impacts on sea turtles in this EIS/OEIS, the quantitative impacts presented herein for non-impulsive TTS are conservative (i.e., over-predicted).

3.5.3.1.3.9 Criteria for Impulsive Temporary Threshold Shift

The sea turtle impulsive TTS threshold, which is based on Type I mid-frequency cetacean data (Southall et al. 2007), should be 178 dB re 1 μPa^2-s. However, during the modeling effort, the T-weighted impulsive TTS threshold of 172 dB re 1 μPa^2-s sound exposure level was inadvertently based on Type II weighted cetacean TTS data rather than Type I weighted cetacean TTS data. This resulted in incorrectly lowering the turtle TTS threshold. Because an incorrectly lowered threshold was used to quantitatively analyze acoustic impacts to sea turtles in this Environmental Impact Statement (EIS)/Overseas EIS (OEIS), the quantitative impacts presented herein for impulsive TTS are conservative (i.e., over-predicted).

3.5.3.1.3.10 Criteria for Non-Impulsive Permanent Threshold Shift

Since no studies were designed to intentionally induce PTS in sea turtles, levels for onset of PTS for these animals must be estimated using TTS data and relationships between TTS and PTS established in terrestrial mammals. PTS can be estimated based on the growth rate of a threshold shift and the level of threshold shift required to potentially become non-recoverable. A variety of terrestrial and marine mammal data sources show that threshold shifts up to 40–50 dB may be recoverable, and that 40 dB is a reasonable upper limit of a threshold shift that does not induce PTS. This analysis assumes that continuous-type exposures producing threshold shifts of 40 dB or more always result in some amount of PTS.

Data from terrestrial mammal testing (Ward et al. 1958, 1959) show TTS growth of 1.5 to 1.6 dB for every 1 dB increase in sound exposure level. The difference between minimum measureable TTS onset (6 dB) and the 40 dB upper safe limit of TTS yields a difference of 34 dB. When divided by a TTS growth rate of 1.6 dB TTS per dB sound exposure level, there is an indication that an increase in exposure of a 21.25 dB sound exposure level would result in 40 dB of TTS. For simplicity and conservatism, the number was rounded down to 20 dB sound exposure level.

Therefore, non-impulse exposures of 20 dB sound exposure level above those producing a TTS may be assumed to produce a PTS. The onset of TTS threshold of 195 dB re 1 µPa^2-s for sea turtles has a corresponding onset of PTS threshold of 215 dB re 1 µPa^2-s. The T-weighting function is applied when using the sound exposure level-based thresholds to predict PTS (see Table 3.5-3).

However, the T-weighted non-impulse TTS threshold of 178 dB re 1 µPa^2-s sound exposure level used during acoustic modeling was inadvertently based on Type II weighted cetacean TTS data rather than Type I weighted cetacean TTS data. This resulted in incorrectly lowering the turtle TTS threshold by 17 dB; consequently, this also incorrectly lowered the sea turtle PTS threshold by 17 dB. The sea turtle non-impulse PTS threshold, based on mid-frequency cetacean data, should be 17 dB higher than 198 dB re 1 µPa^2-s. Because an incorrectly lowered threshold was used to quantitatively analyze acoustic impacts to sea turtles in this EIS/OEIS, the quantitative impacts presented herein for non-impulse PTS are conservative (i.e., over-predicted).

3.5.3.1.3.11 Criteria for Impulsive Permanent Threshold Shift

The sea turtle impulsive PTS threshold, which is based on Type I mid-frequency cetacean data (Southall et al. 2007), should be 198 dB re 1 µPa^2-s. However, during the modeling effort, the T-weighted impulsive PTS threshold of 187 dB re 1 µPa^2-s sound exposure level was inadvertently based on Type II weighted cetacean TTS data rather than Type I weighted cetacean TTS data. This resulted in incorrectly lowering the turtle TTS threshold. Because an incorrectly lowered threshold was used to quantitatively analyze acoustic impacts to sea turtles in this EIS/OEIS, the quantitative impacts presented herein for impulsive TTS are conservative (i.e., over-predicted).

3.5.3.1.3.12 Criteria for Behavioral Responses

A sea turtle's behavioral response to sound is assumed to be variable and context specific. For instance, a single impulse may cause a brief startle reaction. A sea turtle may swim farther away from the sound source, increase swimming speed, change surfacing time, and decrease foraging if the stressor continues to occur. For each potential behavioral change, the magnitude of the change ultimately would determine the severity of the response. It is assumed that most responses would be short-term avoidance reactions.

A few studies reviewed investigated behavioral responses of sea turtles to impulse sounds emitted by airguns (McCauley et al. 2000; Moein Bartol et al. 1995; O'Hara and Wilcox 1990). There are no studies of sea turtle behavioral responses to sonar. Cumulatively, available airgun studies indicate that perception and a behavioral reaction to a repeated sound may occur with sound pressure levels greater than 166 dB re 1 µPa rms, and that more erratic behavior and avoidance may occur at higher thresholds around 175–179 dB re 1 µPa rms (McCauley et al. 2000; Moein Bartol et al. 1995; O'Hara and Wilcox 1990). A received level of 175 dB re 1 µPa rms is more likely to be the point at which avoidance may occur in unrestrained turtles, with a comparable sound exposure level of 160 dB re 1 μPa^2-s (McCauley et al. 2000).

Airgun studies used sources that fired repeatedly over some duration. For single impulses at received levels below threshold shift (hearing loss) levels, the most likely behavioral response is assumed to be a startle response. Since no further sounds follow the initial brief impulse, the biological significance is considered to be minimal.

Based on the limited information regarding significant behavioral reactions of sea turtles to sound, behavioral responses to sounds are qualitatively assessed for sea turtles.

3.5.3.1.4 Quantitative Analysis

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

For quantification of estimated marine mammal and sea turtle impacts resulting from sounds produced during Navy activities, the Navy developed a set of data and new software tools. This new approach is the resulting evolution of the basic modeling approaches used by the Navy previously and reflects a much more complex and comprehensive modeling approach as described below.

3.5.3.1.4.1 Navy Acoustic Effects Model

For this analysis of Navy training and testing activities at sea, the Navy developed a set of software tools and compiled data for quantifying predicted acoustic impacts. These databases and tools collectively form the Navy Acoustics Effects Model. Details of the Navy Acoustics Effects Model processes and the description and derivation of the inputs are presented in the Technical Report (Determination of Acoustic Effects on Marine Mammals and Sea Turtles for Navy Training and Testing Events). The following paragraphs provide an overview of the Navy Acoustics Effects Model process and its more critical data inputs.

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

Using the best available information on the estimated density of sea turtles in the area being modeled, the Navy Acoustics Effects Model derives an abundance (total number individuals) and distributes the resulting number of virtual animals (“animats”) into an area bounded by the maximum distance that energy propagates out to a criterion threshold value (energy footprint). These animats are distributed based on density differences across the area and known depth distributions (dive profiles). Animats change depths every 4 minutes but do not otherwise mimic actual animal behaviors (such as avoidance or attraction to a stimulus).

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

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

The Navy Acoustics Effects Model then tracks the energy received by each animat within the energy footprint of the activity and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds. Predicted effects to the animats within a scenario are then tallied and the highest order effect (based on severity of criteria; e.g., PTS over TTS) predicted for a given animat is assumed. Each scenario or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine animat could be impacted during each independent scenario or 24-hour period. In few instances, although the activities themselves all occur within the Study Area, sound may propagate beyond the boundary of the Study Area. Any exposures occurring outside the boundary of the MITT Study Area are counted as if they occurred within the MITT Study Area boundary.

3.5.3.1.4.2 Model Assumptions

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

- Animats are modeled as being underwater and facing the source and therefore always predicted to receive the maximum sound level at their position within the water column (e.g., the model does not account for conditions such as body shading or an animal raising its head above water).
- Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating temporary or permanent hearing loss, because there are insufficient data to estimate a hearing recovery function for the time between exposures.

- Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological impacts such as hearing loss, especially for slow-moving or stationary sound sources in the model.
- Animats are stationary horizontally and therefore do not avoid the sound source, unlike in the wild where animals would most often avoid exposures at higher sound levels, especially those exposures that may result in permanent hearing loss (PTS).
- Animats receive the full impulse of the initial positive pressure wave due to an explosion, although the impulse-based thresholds (onset mortality and onset slight lung injury) assume an impulse delivery time adjusted for animal size and depth. Therefore, these impacts are overestimated at greater distances and increased depths.
- Mitigation measures implemented during training and testing activities that reduce the likelihood of exposing a sea turtle to higher levels of acoustic energy near the most powerful sound sources (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) were not considered in the model.

3.5.3.1.4.3 Sea Turtle Densities

A quantitative analysis of impacts on a species requires data on the abundance and concentration of the species population in the potentially impacted area. The most appropriate metric for this type of analysis is density, which is the number of animals present per unit area. There is no single source of density data for every area of the world, species, and season because of the fiscal costs, resources, and effort involved in providing survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the Study Area, the Navy compiled data from several sources. To compile and structure the most appropriate database of marine species density data, the Navy developed a protocol to select the best available data sources based on species, area, and time (season). The resulting Geographic Information System database called the Navy Marine Species Density Database (U.S. Department of the Navy 2012) includes seasonal density values for every marine mammal and sea turtle species present within the Study Area. All species density distributions matched the expected distributions from published literature and the NMFS stock assessments. In this analysis, sea turtle density data were used as an input in the Navy Acoustic Effects Model in their original temporal and spatial resolution.

3.5.3.1.5 Impacts from Sonar and Other Active Acoustic Sources

Sonar and other active acoustic sound sources emit sound waves into the water to detect objects, safely navigate, and communicate. These systems are used for anti-submarine warfare, mine warfare, navigation, sensing of oceanographic conditions (e.g., sound speed profile), and communication. General categories of sonar systems are described in Section 2.3 (Descriptions of Sonar, Ordnance/Munitions, Targets, and Other Systems Employed in Mariana Islands Training and Testing Activities) and Section 3.0.5.2.1 (Acoustic Stressors).

Potential direct impacts on sea turtles from exposure to sonar or other non-impulse underwater active acoustic sources include hearing loss due to threshold shift (permanent or temporary), masking of other biologically relevant sounds, physiological stress, or changes in behavior (see Section 3.5.3.1.2, Analysis Background and Framework). Direct injury and barotrauma from a primary blast would not occur from exposure to these sources due to slower rise times and lower peak pressures. As stated above, a TTS can be mild and recovery can take place within a matter of minutes to days and, therefore, is unlikely to cause long-term consequences to individuals or populations. There is no research to indicate whether sea turtles with PTS would suffer long-term consequences. Sea turtles probably do not rely on their auditory systems as a primary sense (Southwood et al. 2008), although little is known about how sea turtles use the narrow range of low-frequency sounds they might perceive in their environment (see Section 3.5.3.1.2.3, Auditory Masking). It is possible that some individuals that experience some degree of permanent hearing loss may have decreased abilities to find resources such as prey or nesting beaches or detect other relevant sounds such as vessel noise, which may lead to long-term consequences for the individual. Similarly, the effect of masking on sea turtles is difficult to assess.

There is little information regarding sea turtle responses to sound. It is anticipated that the intensity of their behavioral response to a perceived sound could depend on several factors, including species, the animal's age, reproductive condition, past experience with the sound exposure, behavior (foraging or reproductive), the received level from the exposure, as well as the type of sound (impulse or non-impulse) and duration of the sound (Appendix H, Biological Resource Methods). Behavioral responses may be short-term (seconds to minutes) and of little immediate consequence for the animal, such as simply orienting to the sound source. Alternatively, there may be a longer term response over several hours such as moving away from the sound source. However, exposure to loud sounds resulting from Navy training and testing at sea would likely be brief because ships and other participants are constantly moving and the animal would likely be moving as well. Animals that are resident during all or part of the year near Navy ports, piers, and near-shore facilities or on fixed Navy ranges are the most likely to experience multiple or repeated exposures. It is likely that a sea turtle could be exposed to sonar and other active acoustic sources multiple times in its lifetime, although the possibility of habituation is unknown. Most exposures would be intermittent and short-term when considered over the duration of a sea turtle's life span. In addition, most sources use frequencies that are higher than the best hearing range of sea turtles.

Most sonar and other active acoustic sources used during training and testing use frequency ranges that are higher than the estimated hearing range of sea turtles (10 Hz to 2 kHz). Therefore, most of these sources have no impact on sea turtle hearing. Only sonar with source levels greater than 160 dB re 1 µPa using frequencies within the hearing range of sea turtles were modeled for potential acoustic impacts on sea turtles. Other active acoustic sources with low source level, narrow beam width, downward directed transmission, short pulse lengths, frequencies above known hearing ranges, or some combination of these factors are not anticipated to result in impacts on sea turtles. These sources are the same or analogous to sound sources analyzed by other agencies and ruled on by NMFS to not result in impacts on protected species, including sea turtles, and therefore were not modeled and are addressed qualitatively in this EIS/OEIS (see Section 3.0.4.1.6 for a discussion of these sources). These sources generally have frequencies greater than 200 kHz and source levels less than 160 dB re 1 µPa. The types of sources with source levels less than 160 dB are primarily hand-held sonars, range pingers, transponders and acoustic communication devices.

Within this acoustics analysis, the numbers of sea turtles that may receive some form of hearing loss were predicted using the Navy Acoustics Effects Model (Section 3.5.3.1.4.1). To quantify the impacts of acoustic exposures to sea turtles, training and testing activities were modeled that employ acoustic sources using frequencies in the hearing range of sea turtles. These activities and the acoustic source classes used are listed in Model-Predicted Impacts. Most sonar and active acoustic sources used during training and testing use frequencies outside of the estimated hearing range of turtles.

3.5.3.1.5.1 Model-Predicted Impacts

Table 3.5-5 and Table 3.5-6 show predicted impacts on sea turtles from the Navy Acoustics Effects Model. The exposure estimates for each alternative represent the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. The predicted acoustic impacts do not take into account avoidance behavior or mitigation measures, such as establishing shut-down zones for certain sonar systems (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). Also see Table 3.4-9 in Section 3.4 (Marine Mammals) for an explanation of the post-model acoustic impact analysis process.

Table 3.5-5: Annual Total Model-Predicted Impacts on Sea Turtles for Training Activities Using Sonar and Other Active Non-Impulse Acoustic Sources

Sea Turtle Species	No Action Alternative		Alternative 1		Alternative 2	
	Temporary Threshold Shift	Permanent Threshold Shift	Temporary Threshold Shift	Permanent Threshold Shift	Temporary Threshold Shift	Permanent Threshold Shift
Green sea turtle	0	0	82	0	104	0
Hawksbill sea turtle	0	0	11	0	13	0
Loggerhead sea turtle	0	0	9	0	12	0
Olive ridley sea turtle	0	0	0	0	0	0
Leatherback sea turtle	0	0	7	0	9	0
TOTAL	**0**	**0**	**109**	**0**	**138**	**0**

Note: The timing, locations, and numbers of these activities would not substantially differ from year to year under each alternative.

Table 3.5-6: Annual Total Model-Predicted Impacts on Sea Turtles for Testing Activities Using Sonar and Other Active Non-Impulse Acoustic Sources

Sea Turtle Species	No Action Alternative		Alternative 1		Alternative 2	
	Temporary Threshold Shift	Permanent Threshold Shift	Temporary Threshold Shift	Permanent Threshold Shift	Temporary Threshold Shift	Permanent Threshold Shift
Green sea turtle	0	0	169	0	170	0
Hawksbill sea turtle	0	0	6	0	7	1
Loggerhead sea turtle	0	0	6	0	6	0
Olive ridley sea turtle	0	0	0	0	0	0
Leatherback sea turtle	0	0	5	0	6	0
TOTAL	**0**	**0**	**186**	**0**	**189**	**1**

Note: The timing, locations, and numbers of these activities would not substantially differ from year to year under each alternative.

3.5.3.1.5.2 No Action Alternative

Training Activities

Training activities under the No Action Alternative include activities that produce non-impulsive sound from the use of sonar and other active acoustic sources that fall within the hearing range of sea turtles. These activities could occur throughout the MITT Study Area open ocean areas. A more detailed description of these activities, the number of activities, and their proposed locations are presented in Table 2.8-1 of Chapter 2 (Description of Proposed Action and Alternatives). Use of sonar and other active acoustic sources during training activities is discussed in Section 3.0.4 (Acoustic and Explosives Primer).

If a source uses a frequency within a sea turtle's hearing range, and if the sea turtle is close enough to perceive the sound, the sea turtle may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. No sea turtles are expected to experience TTS or PTS from the minimal acoustic sources under the No Action Alternative. There are no model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources under the No Action Alternative (see Table 3.5-5). Sea turtles that reside during all or part of the year on a Navy range complex may be exposed several times throughout the year to sound from sonar and other active acoustic sources. Exposures to sonar and other active acoustic sources in open water areas would be intermittent and geographically variable. Pronounced reactions to acoustic stimuli could lead to a sea turtle expending energy and missing opportunities to forage or breed. In most cases acoustic exposures are intermittent, allowing time to recover from an incurred energetic cost, resulting in no long-term consequence.

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley or leatherback sea turtles.

Testing Activities

Testing activities potentially using non-impulsive acoustic sources under the No Action Alternative is restricted to the North Pacific Acoustic Lab Philippine Sea Experiment (Table 2.8-4). Research vessels, acoustic test sources, side scan sonar, ocean gliders, the existing moored acoustic tomographic array and distributed vertical line array, and other oceanographic data collection equipment will be used to collect information on the ocean environment and sound propagation during the 2018 data collection period. Currently, the array is being used to passively collect oceanographic and acoustic data in the region.

If a source uses a frequency within a sea turtle's hearing range, and if the sea turtle is close enough to perceive the sound, the sea turtle may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. No sea turtles are expected to experience TTS or PTS from the minimal acoustic sources under the No Action Alternative. Exposures to acoustic sources in open water areas would be intermittent and limited to the Philippine Sea Experiment. The intermittent acoustic exposures in this limited area would allow time to recover from an incurred energetic cost, resulting in no long-term consequence. Because most impacts would be short-term, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley or leatherback sea turtles.

3.5.3.1.5.3 Alternative 1

Training Activities

The number of annual training activities that produce in-water sound from sonar or other active acoustic sources that falls within the hearing range of sea turtles under Alternative 1 would increase over the No Action Alternative. The number of annual training activities that produce in-water sound from the use of sonar and other active acoustic sources under Alternative 1 would increase over the No Action Alternative (Table 3.0-8).

If a source uses a frequency within a sea turtle's hearing range, and if the sea turtle is close enough to perceive the sound, the sea turtle may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources under the Alternative 1 are shown in Table 3.5-5 for annual training activities. The results shown are the impacts on sea turtles predicted for 1 year of training. The impacts are predicted to increase compared to the No Action Alternative. Based on modeling, 109 TTS exposures and no PTS exposures are expected (Table 3.5-5). While no TTS or PTS was predicted by the Navy Acoustic Effects Model (NAEMO) modeling for olive ridley turtles, they may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. These impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness).

The TTS exposures could temporarily affect perception of sound within a limited frequency range. Sea turtles that reside during all or part of the year on a Navy range complex may be exposed several times throughout the year to sound from sonar and other active acoustic sources. Exposures to sonar and other active acoustic sources in open water areas would be intermittent and geographically variable. Pronounced reactions to acoustic stimuli could lead to a sea turtle expending energy and missing opportunities to forage or breed. In most cases acoustic exposures are intermittent, allowing time to recover from an incurred energetic cost, resulting in no long-term consequence.

The increase in predicted impacts on sea turtles could mean an increase in the number of individual animals exposed per year or an increase in the number of times per year some animals are exposed, when compared to the No Action Alternative. However, the expected impacts on any individual sea turtle remain the same. Similarly, the model may over-predict acoustic impacts because it does not consider avoidance and the criteria to predict impacts are conservative. For the same reasons provided in for the No Action Alternative, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness) to most individuals. Although some individuals may experience long-term impacts, population-level impacts are not expected.

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities under Alternative 1 may affect, and is likely to adversely affect, green, hawksbill, loggerhead, or leatherback sea turtles. The use of sonar and other active acoustic sources during training activities under Alternative 1 may affect, but is not likely to adversely affect olive ridley sea turtles.

Testing Activities

Testing activities under Alternative 1 include activities that produce in-water sound from sonar or other active non-impulse acoustic sources that fall within the hearing range of sea turtles. A detailed description of these activities, the number of activities, and their proposed locations are presented in Tables 2.8-2 to 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives).

Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources under Alternative 1 are shown in Table 3.5-6 for annual testing activities. The impacts are predicted to increase compared to the No Action Alternative.

Although impacts could occur across all of the MITT Study Area due to various types of testing involving active acoustic sources, the portion of total predicted impacts are greater for certain activities, either due to the types of sources or the hours of use. Testing activities using sonar and other active acoustic sources are often multi-day activities during which active sources are used intermittently; therefore, some animals may be exposed multiple times over the course of a few days. Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources are shown in Table 3.5-6 for annual testing activities. The results shown are the impacts on sea turtles predicted for 1 year of testing under Alternative 1. Based on modeling, 186 TTS exposures and 0 PTS exposures are expected (Table 3.5-6). While no TTS or PTS was predicted by the NAEMO modeling for olive ridley turtles, they exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. These impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness).

If a source uses a frequency within a sea turtle's hearing range, and if the sea turtle is close enough to perceive the sound, they exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. The TTS exposures could temporarily affect perception of sound within a limited frequency range. Sea turtles that reside during all or part of the year on a Navy range complex may be exposed several times throughout the year to sound from sonar and other active acoustic sources. Exposures to sonar and other active acoustic sources in open water areas would be intermittent and geographically variable. Pronounced reactions to acoustic stimuli could lead to a sea turtle expending energy and missing opportunities to forage or breed. In most cases acoustic exposures are intermittent, allowing time to recover from an incurred energetic cost, resulting in no long-term consequence.

Because model-predicted impacts are conservative and most impacts would be short-term, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts. Although some individuals may experience long-term impacts, population-level impacts are not expected.

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities under Alternative 1 may affect, and is likely to adversely affect, green, hawksbill, loggerhead, or leatherback sea turtles. The use of sonar and other active acoustic sources during testing activities under Alternative 1 may affect, but is not likely to adversely affect olive ridley sea turtles.

3.5.3.1.5.4 Alternative 2

Training Activities

Training activities under Alternative 2 include activities that produce in-water sound from sonar or other active non-impulse acoustic sources that fall within the hearing range of sea turtles. A detailed description of these activities, the number of activities, and their proposed locations are presented in Tables 2.8-2 to 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives). Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources under the No Action Alternative are shown in Table 3.5-5 for annual training activities. The impacts are predicted to increase compared to the No Action Alternative.

Although impacts could occur across all of the MITT Study Area due to various types of training involving active acoustic sources, the portion of total predicted impacts are greater for certain activities, either due to the types of sources or the hours of use. Training activities using sonar and other active acoustic sources are often multi-day activities during which active sources are used intermittently; therefore, some animals may be exposed multiple times over the course of a few days. Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources are shown in Table 3.5-6 for annual training activities. The results shown are the impacts on sea turtles predicted for 1 year of testing. The impacts are predicted to increase compared to the No Action Alternative. Based on modeling, 138 TTS exposures and no PTS exposures are expected (Table 3.5-5). While no TTS or PTS was predicted by the NAEMO modeling for olive ridley turtles, the sea turtle may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. These impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness).

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities under Alternative 2 may affect, and is likely to adversely affect, green, hawksbill, loggerhead, or leatherback sea turtles. The use of sonar and other active acoustic sources during training activities under Alternative 2 may affect, but is not likely to adversely affect olive ridley sea turtles.

Testing Activities

Testing activities under Alternative 2 include activities that produce in-water sound from sonar or other active non-impulse acoustic sources that fall within the hearing range of sea turtles. A detailed description of these activities, the number of activities, and their proposed locations are presented in Tables 2.8-2 to 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives). Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources under Alternative 2 are shown in Table 3.5-6. The impacts are predicted to increase compared to the No Action Alternative.

Although impacts could occur across the Study Area due to various types of testing involving active acoustic sources, the portion of total predicted impacts are greater for certain activities, either due to the types of sources or the hours of use. Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources for annually recurring testing activities under Alternative 2 are shown in Table 3.5-6. The results shown are the impacts on sea turtles predicted for 1 year of testing. The impacts are predicted to increase compared to the No Action Based on modeling, 189 TTS exposures and 1 PTS exposure could occur under Alternative 2 (Table 3.5-6). PTS due to testing with sonar and other active acoustic sources could permanently reduce perception of sound within a limited frequency range. This long-term consequence could impact an individual turtle’s ability to sense biologically important sounds, such as predators or prey, reducing that animal’s fitness. No TTS or PTS was predicted by the NAEMO modeling for olive ridley turtles, however, the sea turtle may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. These impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness).

Despite the overall number of exposures increasing relative to the No Action Alternative, the modeled impacts on sea turtles are similar. Similarly, the model may over predict acoustic impacts because it does not consider avoidance and the criteria to predict impacts are conservative. For the same reasons provided for Alternative 1, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness) to most individuals. Although some individuals may experience long-term impacts, population-level impacts are not expected.

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities under Alternative 2 may affect, and is likely to adversely affect, green, hawksbill, loggerhead, or leatherback sea turtles. The use of sonar and other active acoustic sources during testing activities Alternative 2 may affect, but is not likely to adversely affect olive ridley sea turtles.

3.5.3.1.6 Impacts from Explosives

Explosions in the water or near the water's surface can introduce loud, impulse, broadband sounds into the marine environment. These sounds are likely within the audible range of most sea turtles, but the duration of individual sounds is very short. Energy from explosions is capable of causing mortalities, injuries to the lungs or gastrointestinal tract, TTS or PTS, or behavioral responses. The impacts on sea turtles from at-sea explosions depend on the net explosive weight of the charge, depth of the charge, the properties of detonations underwater, the animal's distance from the charge, the animal's location in the water column, and environmental factors such as water depth, water temperature, and bottom type. The net explosive weight accounts for the weight and the type of explosive material. Criteria for determining physiological impacts on sea turtles from impulse sound are discussed in Section 3.5.3.1.3 (Acoustic and Explosive Thresholds and Criteria).

Exposures that result in injuries such as non-lethal trauma and PTS may limit an animal's ability to find or obtain food, impact buoyancy, swimming ability, orientation, communicate with other animals, avoid predators, and interpret the environment around them. Impairment of these abilities can decrease an individual's chance of survival or impact its ability to successfully reproduce. Mortality of an animal will remove the animal entirely from the population as well as eliminate its future reproductive potential.

There is some limited information on sea turtle behavioral responses to impulse sound from airgun studies (see Section 3.5.3.1.3, Acoustic and Explosive Thresholds and Criteria) that can be used as a surrogate for explosive impact analysis. Any behavioral response to a single detonation would likely be a short-term startle response, if the animal responds at all. Multiple detonations over a short period may cause an animal to exhibit other behavioral reactions, such as interruption of feeding or avoiding the area.

3.5.3.1.6.1 Model-Predicted Impacts

The ranges to impacts from explosions of different charge weights for each of the specific criteria (onset mortality, onset slight lung injury, onset slight gastrointestinal tract injury, PTS, and TTS) are shown in Table 3.5-7. Sea turtles within these ranges are predicted by the model to receive the associated impact. Information regarding the ranges to impacts is important, not only for predicting acoustic impacts, but also for verifying the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher level impacts, especially physiological impacts on sea turtles. Because propagation of the acoustic waves is affected by environmental factors at different locations and because some criteria are partially based on sea turtle mass, the range of impacts for particular criteria will vary. The low value for each range of impact is the minimum range and the high value is the maximum range within which the impact could occur for various activities modeled for each explosive source class.

Table 3.5-7: Distance Impacts of In-Water Explosives on Sea Turtles from Representative Sources

Criteria/Predicted Impact[1]	Impact Predicted to Occur When Sea Turtle is at this Range (m) or Closer to a Detonation (Minimum Range Predicted to Maximum Range Predicted)			
	Source Class E2 (>0.25–0.5 lb. NEW)	Source Class E5 (>5–10 lb. NEW)	Source Class E9 (>100–250 lb. NEW)	Source Class E12 (>650–1,000 lb. NEW)
Onset Mortality (1 Percent Mortality)	12	47	137	204
Onset Slight Lung Injury	25	87	240	352
Onset Slight GI Tract Injury	25	71	147	274
Permanent Threshold Shift[2]	79	222	587	1,602
Temporary Threshold Shift[2]	178	598	1,711	3,615

[1] Criteria for impacts are discussed in Section 3.5.3.1.3 (Acoustic and Explosive Thresholds and Criteria).
[2] Modeling for Sound Exposure Level-based impulse criteria assumed explosive activity durations of one second. Actual durations may be less, resulting in smaller ranges to impact.
Notes: (1) GI = gastrointestinal, lb. = pounds, m = meters, NEW = net explosive weight
(2) Ranges determined using REFMS, Navy's explosive propagation model.

Based on the estimate of sound exposure level that could induce a sea turtle to exhibit avoidance behavior when exposed to repeated impulse sounds (see Section 3.5.3.1.3.12, Criteria for Behavioral Responses), the distance from an explosion at which a sea turtle may behaviorally react (e.g., avoid by moving farther away) can be estimated. If exposed to a single impulse sound, a sea turtle is assumed to exhibit a brief startle reaction that would likely be biologically insignificant.

Table 3.5-8, Table 3.5-9, and Table 3.5-10 present predicted impacts on sea turtles from explosive detonations estimated by the Navy Acoustic Effects Model, applying the impact threshold criteria shown in Table 3.5-3. The impact estimates for each alternative represent the total number of impacts and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year.

Some of the conservative assumptions made for the impact modeling and criteria may cause the impact predictions to be overestimated, as follows:

- Many explosions from ordnance such as bombs and missiles actually explode upon impact with above-water targets. For this analysis, sources such as these were modeled as exploding at depths of 1 m, overestimating the amount of explosive and acoustic energy entering the water.
- For predicting TTS and PTS based on sound exposure level, the duration of an explosion is assumed to be one second. Actual detonation durations may be much shorter, so the actual sound exposure level at a particular distance may be lower.
- Mortality and slight lung injury criteria are based on juvenile turtle masses, which substantially increases that range to which these impacts are predicted to occur compared to the ranges that would be predicted using adult turtle masses.
- As discussed in Section 3.5.3.1.3.9 (Criteria for Impulsive Temporary Threshold Shift) and Section 3.5.3.1.3.11 (Criteria for Impulsive Permanent Threshold Shift), the thresholds that were used to quantitatively predict onset of TTS and PTS for sea turtles were incorrectly lowered when developing sea turtle acoustic impact criteria based on cetacean data. Therefore, the predicted impacts shown above (PTS and TTS) are conservative (i.e., over-predicted).

Table 3.5-8: Annual Model-Predicted Impacts on Sea Turtles from Explosives for Training Activities under the No Action Alternative

Sea Turtle Species	Temporary Threshold Shift	Permanent Threshold Shift	GI Tract Injury	Slight Lung Injury	Mortality
Green sea turtle	6	0	0	1	0
Hawksbill sea turtle	2	0	0	0	0
Loggerhead sea turtle	0	0	0	0	0
Olive ridley sea turtle	0	0	0	0	0
Leatherback sea turtle	0	0	0	0	0
TOTAL	**8**	**0**	**0**	**1**	**0**

Notes: (1) GI = gastrointestinal. (2) The timing, locations, and numbers of these activities would not substantially differ from year to year under each alternative. The numbers presented in this table reflect post-modeling adjustments which decrease the potential for an impact on sea turtles.

Table 3.5-9: Annual Model-Predicted Impacts on Sea Turtles from Explosives for Training Activities under Alternative 1 and Alternative 2

Sea Turtle Species	Temporary Threshold Shift	Permanent Threshold Shift	GI Tract Injury	Slight Lung Injury	Mortality
Green sea turtle	11	1	0	3	1
Hawksbill sea turtle	3	0	0	1	1
Loggerhead sea turtle	0	0	0	0	0
Olive ridley sea turtle	0	0	0	0	0
Leatherback sea turtle	0	0	0	0	0
TOTAL	**14**	**1**	**0**	**4**	**2**

Notes: (1) GI = gastrointestinal. (2) The timing, locations, and numbers of these activities would not substantially differ from year to year under each alternative. The numbers presented in this table reflect post-modeling adjustments which decrease the potential for an impact on sea turtles.

Table 3.5-10: Annual Model-Predicted Impacts on Sea Turtles from Explosives for Testing Activities under the No Action Alternative, Alternative 1, and Alternative 2

Sea Turtle Species	Temporary Threshold Shift	Permanent Threshold Shift	GI Tract Injury	Slight Lung Injury	Mortality
Green sea turtle	0	0	0	0	0
Hawksbill sea turtle	0	0	0	0	0
Loggerhead sea turtle	0	0	0	0	0
Olive ridley sea turtle	0	0	0	0	0
Leatherback sea turtle	0	0	0	0	0
TOTAL	**0**	**0**	**0**	**0**	**0**

Notes: (1) GI = gastrointestinal. (2) The timing, locations, and numbers of these activities would not substantially differ from year to year under each alternative. The numbers presented in this table reflect post-modeling adjustments which decrease the potential for an impact on sea turtles.

The predicted acoustic impacts do not take into account mitigation measures implemented during many training and testing activities, such as exclusion zones around detonations. Smaller hatchling and early juvenile turtles tend to be near the surface.

3.5.3.1.6.2 No Action Alternative

Training Activities

Under the No Action Alternative, explosions during training activities would be spread throughout the Study Area. Explosions would occur during naval gunnery, missile exercises, bombing exercises, sinking exercise, tracking exercises, and mine warfare. The largest source class used during training under the No Action Alternative would be E12 (> 650–1,000 lb. [> 272.2–453.6 kg] NEW). However, of all explosives used for training under the No Action Alternative (844, Table 3.0-9) only four are of this source class, and this source class is only used in the MITT Study Area at distances greater than 50 nautical miles (nm) from shore. With the exception of those used at FDM and the nearshore underwater detonation sites, the vast majority of all explosives used under the No Action Alternative occur in areas greater than 3 nm from shore. There is a potential (albeit small) for aberrant ordnance at FDM to miss land-based targets and strike the beaches of FDM. However, the terrain of FDM does not provide any sea turtle nesting beaches; therefore, effects on sea turtles are not expected.

Under the No Action Alternative, training activities using explosions that could occur anywhere in the Study Area, including within nearshore shallow areas below the high tide line, are restricted to 50 detonations annually, all of them less than at or below the E5 source class (> 5–10 lb. [> 2.3–4.5 kg] NEW).

Modeling results indicate eight TTS exposures, zero PTS exposures, one exposure resulting in lung injury, and zero exposures resulting in mortality for sea turtles (Table 3.5-8). Any injured sea turtles could suffer reduced fitness and long-term survival. Some sea turtles beyond the ranges of the above impacts may behaviorally react if they hear a detonation. Activities consisting of single detonations, such as bombing and missile exercise, are expected to only elicit short-term behavioral reactions. If a sea turtle hears multiple detonations in a short period, such as during gunnery, firing, or sonobuoy exercises, it may react by avoiding the area. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of detonations and exposures would not occur over long durations, there would be an opportunity to recover from an incurred energetic cost.

Because model-predicted impacts are conservative and most impacts would be short-term, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. Although a few individuals may experience long-term impacts and potential mortality, population-level impacts are not expected.

Pursuant to the ESA, the use of underwater explosives during training activities under the No Action Alternative may affect, and is likely to adversely affect, green and hawksbill sea turtles. Pursuant to the ESA, the use of underwater explosives during training activities under the No Action Alternative may affect, but is not likely to adversely affect loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under the No Action Alternative, there are no testing activities that involve explosive detonations.

3.5.3.1.6.3 Alternative 1

Training Activities

Under Alternative 1, the number of explosives used during training activities would rise from 844 to 9,696 per year and would be spread throughout the MITT Study Area (see Table 3.0-9). Explosives would occur during naval gunnery, missile exercises, bombing exercises, sinking exercise, tracking exercises, and mine warfare. The total number of explosive detonations that could occur in the shallow portions of the MITT Study Area increases. Similar to the No Action Alternative, the source class for these activities is E5 (> 5–10 lb. NEW) or less. The 8,601 additional detonations (less than E5) in all training areas (but potentially in shallow waters) would increase the disturbance of nearshore turtles. Aside from those used at FDM and the nearshore underwater detonation sites, most detonations would typically occur beyond approximately 3 nm from shore, minimizing impacts near nesting beaches or coastal habitats for sea turtles. There is a potential (albeit small) for aberrant ordnance at FDM to miss land-based targets and strike the beaches of FDM. Though detonations occur under Alternative 1 at FDM, the terrain of FDM does not provide any sea turtle nesting beaches; therefore, effects on sea turtles are not expected.

A small number of near-shore (within 3 nm) training activities could occur, potentially exposing some sea turtles approaching nesting beaches to impulse sounds over a short duration if the training occurred during nesting season or close to sea turtles nearshore habitats. In water training activities using lower NEW explosives (up to 20 lb. NEW) will occur at underwater detonation sites within Agat Bay Floating Mine Neutralization Site. At Piti Point Floating Mine Neutralization Site and Apra Harbor Underwater Detonation Site, the maximum NEW would remain the same as with the No Action Alternative (a maximum allowable threshold of 10 lb. NEW).

The remaining activities conducted under Alternative 1 utilizing explosive detonations would be restricted to portions of the MITT Study Area that are greater than 3 nm from the shore. Model-predicted impacts on sea turtles due to explosives used in annually recurring training activities under Alternative 1 are shown in Table 3.5-9. The results shown are the impacts on sea turtles predicted for 1 year of training.

Modeling results indicate 14 TTS exposures, 1 PTS exposure, 4 exposures resulting in lung injury, and 2 exposures resulting in mortality for sea turtles (Table 3.5-9). As mentioned above most detonations would typically occur beyond approximately 3 nm from shore, which minimizes the impacts near nesting beaches or coastal habitats for sea turtles. Any injured sea turtles could suffer reduced fitness and long-term survival. Sea turtles that experience PTS would have permanently reduced perception of sound within a limited frequency range. It is uncertain whether some permanent hearing loss over a part of a sea turtle's hearing range would have long-term consequences for that individual, as the sea turtle hearing range is already limited. A long-term consequence could be an impact on an individual turtle's ability to sense biologically important sounds, such as predators or prey, reducing that animal's fitness. PTS and TTS threshold criteria for sea turtles are conservatively based on criteria developed for mid-frequency marine mammals, so actual PTS and TTS impacts may be less than the predicted quantities.

Some sea turtles beyond the ranges of the above impacts may behaviorally react if they hear a detonation. If a sea turtle hears multiple detonations in a short period, such as during gunnery, firing, or sonobuoy exercises, it may react by avoiding the area. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of detonations and exposures would not occur over long durations, there would be an opportunity to recover from an incurred energetic cost.

Because model-predicted impacts are conservative and most impacts would be short-term, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. Although a few individuals may experience long-term impacts and potential mortality, population-level impacts are not expected.

Pursuant to the ESA, the use of underwater explosives during training activities under Alternative 1 may affect, and is likely to adversely affect, green and hawksbill sea turtles. Pursuant to the ESA, the use of underwater explosives during training activities under Alternative 1 may affect, but is not likely to adversely affect loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Alternative 1 would introduce 2,885 explosive detonations per year (see Table 3.0-9). Over 90 percent of these activities occur at distances greater than 3 nm from shore within the MIRC. Model-predicted acoustic impacts on sea turtles due to explosives during annually recurring testing activities under Alternative 1 are shown in Table 3.5-10. The results shown are the impacts on sea turtles predicted for 1 year of testing. Modeling results indicate no exposures at the level predicted to cause TTS, PTS, gastrointestinal injury, lung injury, or mortality for sea turtles. Although a few individuals may experience behavioral reactions, population-level impacts are not expected.

Pursuant to the ESA, the use of underwater explosives during testing activities under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.6.4 Alternative 2

Training Activities

Under Alternative 2, the number and location of training activities increases to 9,992 explosive detonations (see Table 3.0-9); however, the new events are restricted to areas greater than 50 nm from the shore in the MITT Study Area. Model-predicted impacts on sea turtles due to explosives used in annually recurring training activities under Alternative 2 are shown in Table 3.5-9, and are identical to those for Alternative 1. The results shown are the impacts on sea turtles predicted for 1 year of training.

These results are the same as for Alternative 1; therefore, the impacts under Alternative 2 are expected to be the same as Alternative 1.

Pursuant to the ESA, the use of underwater explosives during training activities under Alternative 1 may affect, and is likely to adversely affect, green and hawksbill sea turtles. Pursuant to the ESA, the use of underwater explosives during training activities under Alternative 2 may affect, but is not likely to adversely affect, leatherback, loggerhead, and olive ridley sea turtles.

Testing Activities

Alternative 2 would increase the number of explosive detonations to 3,431 (see Table 3.0-9). Over 92 percent of these testing activities occur in waters greater than 3 nm from shore within the Study Area. Model-predicted acoustic impacts on sea turtles due to explosions during annually recurring testing activities under Alternative 2 are shown in Table 3.5-10. Modeling results indicate no exposures at levels expected to cause TTS, PTS, gastrointestinal injury, lung injury, or mortality for sea turtles. Although a few individuals may experience behavioral reactions only, population-level impacts are not expected.

Pursuant to the ESA, the use of underwater explosives during testing activities under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley and leatherback sea turtles.

3.5.3.1.7 Impacts from Swimmer Defense Airguns

Airguns can introduce brief impulse, broadband sounds into the marine environment. These sounds are probably within the audible range of most sea turtles. Sounds from airguns are capable of causing PTS or TTS or behavioral responses. Single, small swimmer defense airguns would not cause direct trauma to sea turtles. Impulses from these small airguns lack the strong shock wave and rapid pressure increases of explosions that can cause primary blast injury or barotraumas. The limited information on assessing sea turtle behavioral responses to impulse sounds is discussed in Section 3.5.3.1.2.5 (Behavioral Reactions).

The behavioral response of sea turtles to the repeated firing of airguns has been studied for seismic survey airguns (e.g., oil and gas exploration). Sea turtles were shown to avoid higher-level exposures or to agitate when exposed to higher-level sources. However, the airguns proposed for use in Navy testing are smaller, and fire a limited number of times, so reactions would likely be lesser than those observed in studies.

Activities that use airguns as part of Navy testing activities would only occur at pierside locations in Apra Harbor; therefore, sea turtles outside of these areas would not be affected.

3.5.3.1.7.1 Model-Predicted Impacts

For the analysis of hearing loss, airguns are treated as any other impulse sound source. Estimates of the number of sea turtles exposed to levels capable of causing these impacts were calculated using the Navy Acoustic Effects Model.

3.5.3.1.7.2 No Action Alternative

Training Activities

Training activities under the No Action Alternative do not use airguns.

Testing Activities

Testing activities under the No Action Alternative do not use airguns.

3.5.3.1.7.3 Alternatives 1 and 2

Training Activities

Training activities under Alternative 1 and 2 do not use airguns.

Testing Activities

Testing activities that impart underwater impulse noise from airguns under Alternative 1 and 2 include pierside integrated swimmer defense testing activities at pierside locations, as described in Table 2.8-3. Small airguns (60 cubic inches) would release impulses into waters around Navy piers in Apra Harbor during 11 annual activities. These areas are industrial, and the waterways carry a high volume of vessel traffic in addition to Navy vessels. These areas tend to have high ambient noise levels sea turtles are not expected because of the high levels of human activity.

Pursuant to the ESA, noise from swimmer defense airguns testing activities under Alternative 1 or Alternative 2 would have no effect on green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.8 Impacts from Weapons Firing, Launch, and Impact Noise

Sea turtles may be exposed to weapons firing and launch noise and noises from the impact of non-explosive ordnance on the water's surface. The noises produced by these activities are described in Section 3.0.5.2.1.4 (Weapons Firing, Launch, and Impact Noise). Reactions by sea turtles to these specific stressors have not been recorded; however, sea turtles may be expected to react to weapons firing, launch, and non-explosive impact noise as they would other transient sounds.

Sea turtles exposed to firing, launch, and non-explosive impact noise may exhibit brief startle reactions, avoidance, diving, or no reaction at all. Gunfire noise would typically consist of a series of impulse sounds. Due to the short term, transient nature of gunfire noise, animals are may be exposed multiple noises but over a short time period. Launch noise would be transient and of short duration, lasting no more than a few seconds at any given location as a projectile travels. Many missiles and targets are launched from aircraft, which would produce minimal noise in the water due to the altitude of the aircraft at launch. Any launch noise transmitted into the water would likely be due only to launches from vessels. Most activities would consist of single launches. Non-explosive bombs, missiles, and targets could impact the water with great force and produce a short duration impulse noise underwater that would depend on the size, weight, and speed of the object at impact.

Sea turtles that are within the area of any of these noises would likely alert, startle, dive, or avoid the immediate area. An animal near the surface directly beneath the firing of a large gun may possibly experience sound exposure levels sufficient to cause a threshold shift; however, this potential impact may be unlikely if a sea turtle reacts to the presence of the vessel prior to a large gunfire activity.

3.5.3.1.8.1 No Action Alternative

Training Activities

Training activities under the No Action Alternative include activities that produce in-water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface. Activities could occur throughout the Study Area.

A sea turtle very near a launch or impact location could experience hearing impacts, although the potential for this effect has not been studied and a sea turtle may avoid vessel interactions prior to the firing of a gun. Sea turtles that experience PTS would have permanently reduced perception of sound within a limited frequency range. It is uncertain whether some permanent hearing loss over a part of a sea turtle's hearing range would have long-term consequences for that individual, as the sea turtle hearing range is already limited. A long-term consequence could be an impact on an individual turtle's ability to sense biologically important sounds, such as predators or prey, reducing that animal's fitness. TTS would result in short-term reduced perception of sound within a limited frequency range, lasting from minutes to days, depending on the exposure.

Any behavioral reactions would likely be short-term and consist of brief startle reactions, avoidance, or diving. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of firings or launches and would not occur over long durations, there would be an opportunity to recover from an incurred energetic cost.

Although some individuals may be impacted by activities that include weapons firing, launch, and non-explosive impact, population-level impacts are not expected.

Pursuant to the ESA, noise from weapons firing, launch, and non-explosive impact during training activities under the No Action Alternative may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing activities under the No Action Alternative do not include weapons firing, launch, and impact noise (Tables 2.8-2 through 2.8-4).

3.5.3.1.8.2 Alternative 1

Training Activities

Training activities under the Alternative 1 that produce in-water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface would increase compared to the No Action Alternative. The locations and types of activities would be similar to those under the No Action Alternative. The number of activities and their proposed locations are described in Table 2.8-1 of Chapter 2 (Description of Proposed Action and Alternatives).

Although the impacts on sea turtles are expected to increase under Alternative 1 compared to the No Action Alternative, the expected impacts on any individual sea turtle would remain the same. For the same reasons provided for the No Action Alternative, although some individuals may be impacted by activities that include weapons firing, launch, and non-explosive impact, population-level impacts are not expected.

Pursuant to the ESA, noise from weapons firing, launch, and non-explosive impact during training activities under Alternative 1 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing activities under Alternative 1 include activities that produce in-water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface. Activities are spread throughout the MITT Study Area during air-to-surface missile tests, kinetic energy weapon testing, and anti-surface warfare mission package testing as described in Tables 2.8-2 through 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives).

A sea turtle very near a launch or impact location could experience hearing impacts, although the potential for this effect has not been studied and a sea turtle may avoid vessel interactions prior to the firing of a gun. Sea turtles that experience PTS would have permanently reduced perception of sound within a limited frequency range. It is uncertain whether some permanent hearing loss over a part of a sea turtle's hearing range would have long-term consequences for that individual, as the sea turtle hearing range is already limited. A long-term consequence could be an impact on an individual turtle's ability to sense biologically important sounds, such as predators or prey, reducing that animal's fitness. TTS would result in short-term reduced perception of sound within a limited frequency range, lasting from minutes to days, depending on the exposure.

Any behavioral reactions would likely be short-term and consist of brief startle reactions, avoidance, or diving. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of firings or launches and would not occur over long durations, there would be an opportunity to recover from an incurred energy cost.

Although some individuals may be impacted by activities that include weapons firing, launch, and non-explosive impact, population-level impacts are not expected.

Pursuant to the ESA, noise from weapons firing, launch, and non-explosive impact during testing activities under Alternative 1 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.8.3 Alternative 2

Training Activities

The number and location of training activities under Alternative 2 are identical to training activities under Alternative 1. Therefore, impacts and comparisons to the No Action Alternative will also be identical.

Pursuant to the ESA, noise from weapons firing, launch, and non-explosive impact during training activities under Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing activities under Alternative 2 include activities that produce in-water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface. Activities are spread throughout the MITT Study Area during air-to-surface missile tests, kinetic energy weapon testing anti-submarine warfare tracking tests, and anti-surface warfare mission package testing as described in Tables 2.8-2 and 2.8-3 of Chapter 2 (Description of Proposed Action and Alternatives).

A sea turtle very near a launch or impact location could experience hearing impacts, although the potential for this effect has not been studied and a sea turtle may avoid vessel interactions prior to the firing of a gun. Sea turtles that experience PTS would have permanently reduced perception of sound within a limited frequency range. It is uncertain whether some permanent hearing loss over a part of a sea turtle's hearing range would have long-term consequences for that individual, as the sea turtle hearing range is already limited. A long-term consequence could be an impact on an individual turtle's ability to sense biologically important sounds, such as predators or prey, thereby reducing that animal's fitness. TTS would result in short-term reduced perception of sound within a limited frequency range, lasting from minutes to days, depending on the exposure.

Any behavioral reactions would likely be short-term and consist of brief startle reactions, avoidance, or diving. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of firings or launches and would not occur over long durations, there would be an opportunity to recover from an incurred energy cost.

Although some individuals may be impacted by activities that include weapons firing, launch, and non-explosive impact, population-level impacts are not expected.

Pursuant to the ESA, noise from weapons firing, launch, and non-explosive impact during testing activities under Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.9 Impacts from Vessel and Aircraft Noise

Vessel Noise

Vessel movements could occur throughout the Study Area, although some portions would have limited or no activity. Many ongoing and proposed training and testing activities within the MITT Study Area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels). Activities involving vessel movements occur intermittently, and are variable in duration, ranging from a few hours up to 2 weeks. Additionally, a variety of smaller craft are operated within the Study Area. Small craft types, sizes, and speeds vary. During training, speeds generally range from 10 to 14 knots; however, ships and craft can and will, on occasion, operate within the entire spectrum of their specific operational capabilities. A detailed description of vessel noise is provided in Section 3.0.5.2.1.5 (Vessel Noise).

Vessel noise could disturb sea turtles and potentially elicit an alerting, avoidance, or other behavioral reaction. Sea turtles are frequently exposed to research, ecotourism, commercial, government, and private vessel traffic. Some sea turtles may have habituated to vessel noise, and may be more likely to respond to the sight of a vessel rather than the noise of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Any reactions are likely to be minor and short-term avoidance reactions, leading to no long-term consequences for the individual or population.

Auditory masking can occur from vessel noise, potentially masking biologically important sounds (e.g., sounds of prey or predators) that sea turtles may rely upon. Potential for masking can vary depending on the ambient noise level within the environment); the received level and frequency of the vessel noise; and the received level and frequency of the sound of biological interest. Masking by passing ships or other sound sources transiting the MITT Study Area would be short-term and intermittent, and therefore unlikely to result in any substantial energetic costs or consequences to individual animals or populations. Areas with increased levels of ambient noise from anthropogenic noise sources, such as areas around busy shipping lanes and near harbors and ports, may cause sustained levels of auditory masking for sea turtles, which could reduce an animal's ability to find prey, find mates, avoid predators, or navigate. However, Navy vessels make up a very small percentage of the overall traffic and the rise of ambient noise levels in these areas is a problem related to all ocean users including commercial and recreational vessels and shoreline development and industrialization.

Surface combatant ships (e.g., guided missile destroyer, guided missile cruiser, and Littoral Combat Ship) and submarines are designed to be very quiet to evade enemy detection. While surface combatants and submarines may be detectable by sea turtles over ambient noise levels at distances of up to a few kilometers, any auditory masking would be minor and temporary. Other Navy ships and small craft have higher source levels, similar to equivalently sized commercial ships and private vessels. Ship noise tends to be low-frequency and broadband; therefore, it may have the largest potential to mask all sea turtle hearing. Noise from large vessels and outboard motors on small craft can produce source levels of 160 dB to over 200 dB re 1 µPa at 1 m for some large commercial vessels and outboard engines. Therefore, in the open ocean, noise from noncombatant Navy vessels may be detectable over ambient levels for tens of kilometers, and some auditory masking is possible. In noisier nearshore areas around Navy ports and ranges, vessel noise may be detectable above ambient for only several hundred meters. Some auditory masking to sea turtles is likely from noncombatant Navy vessels, especially in quieter, open-ocean environments.

An approaching vessel may produce a noise shadow when the propulsion system is located at the rear of the vessel. The vessels that pose the greatest risk to sea turtles are small, fast-moving vessels typically used in coastal waters where sea turtle abundance is the greatest (Chaloupka et al. 2008b). These boats typically have propeller configurations above the depth of the keel, shielding noise waves from projecting forward of the vessel (Gerstein et al. 2009). Noise levels in front of the approaching vessel are lower because the ship's hull blocks the noise produced by the propulsion system (Gerstein et al. 2009). Low-frequency noises are refracted around the ship's hull, as shown by Gerstein et al. (2009), while mid-frequency and high frequency noises are refracted outward from the vessel trajectory. In response, marine animals that hear in the middle and high frequencies may move to a position closer to the approaching vessel's bow trajectory, increasing the potential for a strike. Low-frequency specialists, such as sea turtles, are less likely to be confused by a noise shadow produced by an approaching vessel because the noise shadow contains low-frequency noises. The potential for vessel strikes is discussed in more detail in Section 3.5.3.3 (Physical Disturbance and Strike Stressors). Navy ships make up a small portion of the total ship traffic, even in the most concentrated port and nearshore areas; therefore, proposed Navy vessel transits are unlikely to cause long-term abandonment of habitat by sea turtles.

Aircraft Noise

Fixed and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area. Sea turtles may be exposed to aircraft noise wherever aircraft overflights occur in the Study Area. Most of these noises would be centered around airbases and fixed ranges within each range complex. Aircraft produce extensive airborne noise from either turbofan or turbojet engines. Rotary-wing aircraft (helicopters) produce low-frequency noise and vibration (Pepper et al. 2003). A severe but infrequent type of aircraft noise is the sonic boom, produced when the aircraft exceeds the speed of sound. A detailed description of aircraft noise as a stressor is provided in Section 3.0.5.2.1.6 (Aircraft Overflight Noise).

Transmission of noise from a moving airborne source to a receptor underwater is influenced by numerous factors, but significant acoustic energy is primarily transmitted into the water directly below the craft in a narrow cone area, as discussed in greater detail in Section 3.0.4, Acoustic and Explosives Primer. Underwater noises from aircraft are strongest just below the surface and directly under the aircraft, and attenuate (reduce in level) with increasing depth. The maximum noise levels in water from aircraft overflights (Table 3.0-12) are approximately 148 dB re 1 µPa for an F/A-18 aircraft at 1,000 ft. (304.8 m) altitude; approximately 125 dB re 1 µPa for an H-60 helicopter hovering at 50 ft. (15.2 m); and under ideal conditions, sonic booms (Table 3.0-13) from aircraft at 1,000 ft. (304.8 m) could reach up to 178 dB re 1 µPa at the water's surface (see Section 3.0.5.2.1.6, Aircraft Overflight Noise, for additional information on aircraft sonic booms).

Sea turtles may respond to both the physical presence and to the noise generated by aircraft, making causation by one or the other stimulus difficult to determine. In addition to noise, all low-flying aircraft create shadows, to which animals at the surface may react. Helicopters may also produce strong downdrafts, a vertical flow of air that becomes a surface wind, which can also affect an animal's behavior at or near the surface.

In most cases, exposure of a sea turtle to fixed-wing or rotary-wing aircraft would last for only seconds as the aircraft quickly passes overhead. Animals would have to be at or near the surface at the time of an overflight to be exposed to appreciable noise levels. Take-offs and landings occur at established airfields as well as on vessels at sea across the Study Area. Take-offs and landings from Navy vessels could startle sea turtles; however, these activities only produce in-water noise at any given location for a brief period as the aircraft climbs to cruising altitude. Some sonic booms from aircraft could startle sea turtles, but these activities are transient and happen infrequently at any given location within the Study Area. Repeated exposure to most individuals over short periods (days) is unlikely, except for animals that reside in nearshore areas around Navy ports, or on Navy fixed-ranges, or during major training exercises.

Low flight altitudes of helicopters during some activities, which often occur under 100 ft. (30.5 m) altitude, may elicit a somewhat stronger behavioral response due to the proximity to the water; the slower airspeed and therefore longer exposure duration; and the downdraft created by the helicopter's rotor. Sea turtles would likely avoid the area under the helicopter. An individual likely would not be exposed repeatedly for long periods because these activities typically transit open ocean areas within the Study Area.

3.5.3.1.9.1 No Action Alternative

Training Activities

Training activities under the No Action Alternative include noise from vessel movements and fixed- and rotary-wing aircraft overflights. Navy vessel and aircraft traffic associated with training could occur in all of the range complexes and throughout the MITT Study Area while in transit.

Most vessel traffic would be concentrated in waters near naval port facilities, as well as smaller craft concentrations near training areas. Therefore, the majority of noise introduced into the water by vessel movements would be concentrated in these areas.

Helicopters typically train closer to shore and at lower altitudes than fixed-wing aircraft. Sea turtles foraging in shallow waters may be exposed to in-water noise from helicopter overflights. Sea turtles exposed to a passing Navy vessel or aircraft may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to aircraft or vessels are not likely to disrupt major behavioral patterns or to result in serious injury to any sea turtles. Acoustic masking may occur due to vessel noises, especially from noncombatant ships. Acoustic masking may prevent an animal from perceiving biologically relevant sounds during the period of exposure, potentially resulting in missed opportunities to obtain resources.

Long-term impacts due to the proposed activities are unlikely because the density of Navy ships in the MITT Study Area is low overall and many Navy ships are designed to be as quiet as possible. Abandonment of habitat is unlikely due to proposed Navy activities because of the low overall density of Navy vessel and aircraft in the Study Area. No long-term consequences for individuals or the population would be expected.

Pursuant to the ESA, noise from vessels and aircraft during training activities under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing activities under the No Action Alternative include noise from vessel movements and. Sea turtles exposed to a passing Navy vessel may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to vessels are not likely to disrupt major behavioral patterns or to result in serious injury to any sea turtles. Acoustic masking may occur due to vessel noises, especially from noncombatant ships. Acoustic masking may prevent an animal from perceiving biologically relevant sounds during the period of exposure, potentially resulting in missed opportunities to obtain resources.

Long-term impacts due to the proposed activities are unlikely because the density of Navy ships in the MITT Study Area is low overall and many Navy ships are designed to be as quiet as possible. Abandonment of habitat is unlikely due to proposed Navy activities because of the low overall density of Navy vessels in the Study Area. No long-term consequences for individuals or the population would be expected.

Pursuant to the ESA, noise from vessels during testing activities under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.9.2 Alternative 1

Training Activities

Training activities proposed under Alternative 1 would increase vessel traffic and aircraft flight hours compared to the No Action Alternative, increasing overall amounts of aircraft and vessel noise. Certain portions of the Study Area, such as areas near Navy ports and training ranges are used more heavily by vessels and aircraft than other portions of the Study Area. The types and locations of noise from vessels and aircraft would be similar to those under the No Action Alternative.

Although more sea turtle exposures to noise from vessels and aircraft could occur, predicted impacts from vessel or aircraft noise would not differ substantially from those under the No Action Alternative.

Significant behavioral reactions by sea turtles due to passing vessel or aircraft noise are not expected (for the same reasons stated for the No Action Alternative), even though the noise may cause short-term impacts, no long-term consequences for individuals or populations would be expected.

Pursuant to the ESA, noise from vessels and aircraft during training activities under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing activities proposed under Alternative 1 would increase Navy vessel traffic and aircraft overflights compared to the No Action Alternative, increasing overall amounts of vessel and aircraft noise. New vessels proposed for testing under Alternative 1 (see Section 2.7.3.2, Ships), such as the Littoral Combat Ship, are all fast-moving and designed to operate in nearshore waters. Overall noise levels may increase in these environments. The number of activities and proposed locations are discussed in further detail in Tables 2.8-2 through 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.5.2.1.5 (Vessel Noise), and Section 3.0.5.2.1.6 (Aircraft Overflight Noise).

Although more sea turtle exposures to noise from vessels and aircraft could occur, predicted impacts from vessel would not differ substantially from those under the No Action Alternative. Sea turtles exposed to a passing Navy aircraft may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to aircraft are not likely to disrupt major behavioral patterns or to result in serious injury to any sea turtles. Significant behavioral reactions by sea turtles due to passing vessel or aircraft noise are not expected. For the same reasons stated for the No Action Alternative, even though the noise may cause short-term impacts, no long-term consequences for individuals or populations would be expected.

Pursuant to the ESA, noise from vessels and aircraft during testing activities under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.9.3 Alternative 2

Training Activities

The number and location of training activities under Alternative 2 are identical to training activities under Alternative 1. Therefore, impacts and comparisons to the No Action Alternative will also be identical.

Pursuant to the ESA, noise from vessels and aircraft during training activities under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing Activities proposed under Alternative 2 would increase Navy vessel traffic and aircraft overflights compared to the No Action Alternative, increasing overall amounts of vessel and aircraft noise. The types of activities and their locations would similar to those under Alternative 1, although overall activities would increase very slightly. The number of activities and proposed locations are discussed in further detail in Tables 2.8-2 and 2.8-3 of Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.5.2.1.5 (Vessel Noise), and Section 3.0.5.2.1.6 (Aircraft Overflight Noise).

Although more sea turtle exposures to noise from vessels and aircraft could occur, predicted impacts from vessel or aircraft noise would not differ substantially from those under Alternative 1. Significant behavioral reactions by sea turtles due to passing vessel or aircraft noise are not expected. For the same reasons stated for the No Action Alternative, even though vessel may cause short-term impacts, no long-term consequences for individuals or populations would be expected. Similarly, although aircraft noise may cause short-term impacts, no long-term consequences for individuals or populations would be expected.

Pursuant to the ESA, noise from vessels and aircraft during testing activities under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.2 Energy Stressors

This section evaluates the potential for sea turtles to be impacted by electromagnetic devices used during training and testing activities in the Study Area.

3.5.3.2.1 Impacts from Electromagnetic Devices

Several different types of electromagnetic devices are used during training and testing activities. For a discussion of the types of activities that use electromagnetic devices, where they are used, and how many activities will occur under each alternative, please see Section 3.0.5.2.2.1 (Electromagnetic Devices).

Well over a century ago, electromagnetic fields were introduced into the marine environment within the MITT Study Area from a wide variety of sources (e.g., power transmission cables), yet little is known about the potential impacts of these sources. Studies on behavioral responses to magnetic fields have been conducted on green and loggerhead sea turtles. Loggerheads were found to be sensitive to field intensities ranging from 0.0047 to 4000 microteslas, and green sea turtles were found to be sensitive to field intensities from 29.3 to 200 microteslas (Normandeau et al. 2011). Because these data are the best available information, this analysis assumes that the responses would be similar for other sea turtle species.

Sea turtles use geomagnetic fields to navigate at sea, and therefore changes in those fields could impact their movement patterns (Lohmann and Lohmann 1996; Lohmann et al. 1997). Turtles in all life stages orient to the earth's magnetic field to position themselves in oceanic currents; this helps them locate seasonal feeding and breeding grounds and to return to their nesting sites (Lohmann and Lohmann 1996; Lohmann et al. 1997). Experiments show that sea turtles can detect changes in magnetic fields, which may cause them to deviate from their original direction (Lohmann and Lohmann 1996; Lohmann et al. 1997). For example, Lohmann and Lohmann (1996) found that loggerhead hatchlings tested in a magnetic field of 52,000 nanoteslas swam eastward, and when the field was decreased to 43,000 nanoteslas, the hatchlings swam westward. Sea turtles also use nonmagnetic cues for navigation and migration, and these additional cues may compensate for variations in magnetic fields.

3.5.3.2.1.1 No Action Alternative

<u>Training Activities</u>

Under the No Action Alternative, there are no training activities that involve the use of electromagnetic devices.

Testing Activities

Under the No Action Alternative, there are no testing activities that involve the use of electromagnetic devices.

3.5.3.2.1.2 Alternative 1

Training Activities

As indicated in Section 3.0.5.2.2.1 (Electromagnetic Devices), training activities involving electromagnetic devices under Alternative 1 occur up to five times annually as part of mine countermeasure (MCM) (towed mine detection) and Civilian Port Defense activities. Table 2.8-1 lists the number and location of training activities that use electromagnetic devices. All sea turtle species in the MITT Study Area could potentially occur in these locations and would have the potential to be exposed to the electromagnetic fields.

If located in the immediate area (within about 650 ft. [198 m]) where electromagnetic devices are being used, sea turtles could deviate from their original movements (as shown by Normandeau et al. 2011), but the extent of this disturbance is likely to be inconsequential. The electromagnetic devices used in training activities are not expected to cause more than a short-term behavioral disturbance to sea turtles because of the: (1) relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m from the source), (2) very localized potential impact area, and (3) temporary duration of the activities (hours). Potential impacts of exposure to electromagnetic stressors are not expected to result in substantial changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

In comparison to the No Action Alternative, the increase in activities presented in Alternative 1 may increase the risk of sea turtle exposures to electromagnetic energy. However, the use of electromagnetic devices is not expected to cause more than a short-term behavioral disturbance to sea turtles or have any lasting effects on their survival, growth, recruitment, or reproduction.

Pursuant to the ESA, the use of electromagnetic devices during training activities under Alternative 1 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Mission package testing for new ship systems includes the use of electromagnetic devices (magnetic fields generated underwater to detect mines). Under Alternative 1, the Naval Sea Systems Command will engage in up to 32 MCM mission package testing activities. All sea turtle species in the MITT Study Area could potentially occur in these locations and would have the potential to be exposed to the electromagnetic fields.

If located in the immediate area (within about 650 ft. [198 m]) where electromagnetic devices are being used, sea turtles could deviate from their original movements (as shown by Normandeau et al. 2011), but the extent of this disturbance is likely to be inconsequential. The electromagnetic devices used in testing activities are not expected to cause more than a short-term behavioral disturbance to sea turtles because of the: (1) relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m from the source), (2) very localized potential impact area, and (3) temporary duration of the activities (hours). Potential impacts of exposure to electromagnetic stressors are not expected to result in substantial changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

In comparison to the No Action Alternative, the increase in activities presented in Alternative 1 may increase the risk of sea turtle exposures to electromagnetic energy. However, the use of electromagnetic devices is not expected to cause more than a short-term behavioral disturbance to sea turtles or have any lasting effects on their survival, growth, recruitment, or reproduction.

Pursuant to the ESA, the use of electromagnetic devices during testing activities under Alternative 1 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.2.1.3 Alternative 2

Training Activities

As indicated in Section 3.0.5.2.2.1 (Electromagnetic Devices), training activities involving electromagnetic devices under Alternative 2 occur up to five times annually as part of MCM (towed mine detection) and Civilian Port Defense activities. Table 2.8-1 lists the number and location of training activities that use electromagnetic devices.

If located in the immediate area (within about 650 ft. [198 m]) where electromagnetic devices are being used, sea turtles could deviate from their original movements (as shown by Normandeau et al. 2011), but the extent of this disturbance is likely to be inconsequential. The electromagnetic devices used in training activities are not expected to cause more than a short-term behavioral disturbance to sea turtles because of the: (1) relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m from the source), (2) very localized potential impact area, and (3) temporary duration of the activities (hours). Potential impacts of exposure to electromagnetic stressors are not expected to result in substantial changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

In comparison to the No Action Alternative, the increase in activities presented in Alternative 2 may increase the risk of sea turtle exposures to electromagnetic energy. However, the use of electromagnetic devices is not expected to cause more than a short-term behavioral disturbance to sea turtles or have any lasting effects on their survival, growth, recruitment, or reproduction.

Pursuant to the ESA, the use of electromagnetic devices during training activities under Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Mission package testing for new ship systems includes the use of electromagnetic devices (magnetic fields generated underwater to detect mines). Under Alternative 2, the Naval Sea Systems Command will engage in up to 36 MCM mission package testing activities. All sea turtle species in the MITT Study Area could potentially occur in these locations and would have the potential to be exposed to the electromagnetic fields.

If located in the immediate area (within about 650 ft. [198 m]) where electromagnetic devices are being used, sea turtles could deviate from their original movements (as shown by Normandeau et al. 2011), but the extent of this disturbance is likely to be inconsequential. The electromagnetic devices used in testing activities are not expected to cause more than a short-term behavioral disturbance to sea turtles because of the: (1) relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m from the source), (2) very localized potential impact area, and (3) temporary duration of the activities (hours). Potential impacts of exposure to electromagnetic stressors are not expected to result in substantial changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

In comparison to the No Action Alternative, the increase in activities presented in Alternative 2 may increase the risk of sea turtle exposures to electromagnetic energy. However, the use of electromagnetic devices is not expected to cause more than a short-term behavioral disturbance to sea turtles or have any lasting effects on their survival, growth, recruitment, or reproduction.

Pursuant to the ESA, the use of electromagnetic devices during testing activities under Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.3 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance and strike stressors used by Navy during training and testing activities within the Study Area. The physical disturbance and strike stressors that may impact sea turtles include: (1) vessels, (2) in-water devices, (3) military expended materials, and (4) seafloor devices. Sections 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources) through 3.0.5.2.1.4 (Weapons Firing, Launch, and Impact Noise) contain the analysis of the potential for disturbance visual or acoustic cues. For a list of Navy activities that involve this stressor, refer to Table 3.0-7 (Stressors by Warfare and Testing Area).

The way a physical disturbance may affect a sea turtle would depend in part on the relative size of the object, the speed of the object, the location of the sea turtle in the water column, and the behavioral reaction of the sea turtle. It is not known at what point or through what combination of stimuli (visual, acoustic, or through detection in pressure changes) a sea turtle becomes aware of a vessel or other potential physical disturbances prior to reacting or being struck. Like marine mammals, if a sea turtle reacts to physical disturbance, the individual must stop its activity and divert its attention in response to the stressor. The energetic costs of reacting to a stressor are dependent on the specific situation, but one can assume that the caloric requirements of a response may reduce the amount of energy available for other biological functions. Given that the presentation of a physical disturbance should be very rare and brief, the cost from the response is likely to be within the normal variation experienced by a sea turtle during its daily routine unless the animal is struck. If a strike does occur, the cost to the individual could range from slight injury to death.

3.5.3.3.1 Impacts from Vessels

The majority of the training and testing activities under all alternatives involve some level of vessel activity. For a discussion of the types of activities that include the use of vessels, where they are used, and the speed and size characteristics of vessels used, see Section 3.0.5.2.3.2 (Vessels). Vessels include ships, submarines and boats ranging in size from small, 22 ft. (7 m) rigid hull inflatable boats to aircraft carriers with lengths up to 1,092 ft. (333 m). Large Navy ships generally operate at speeds in the range of 10 to 15 knots, and submarines generally operate at speeds in the range of 8 to 13 knots. Small craft (for purposes of this discussion less than 40 ft. [12 m] in length) have much more variable speeds (dependent on the mission). While these speeds are representative of most activities, some vessels need to operate outside of these parameters. For example, in order to produce the required relative wind speed over the flight deck, an aircraft carrier vessel group engaged in flight operations must adjust its speed through the water accordingly. Conversely, there are other instances such as launch and recovery of a small rigid hull inflatable boat, vessel boarding, search, and seizure training activities or retrieval of a target when vessels will be dead in the water or moving slowly ahead to maintain steerage. There are a few specific activities including high speed tests of newly constructed vessels such as aircraft carriers, amphibious assault ships and the Joint High Speed Vessel (which will operate at an average speed of 35 knots) where vessels will operate at higher speeds.

The number of Navy vessels in the MITT Study Area at any given time varies and is dependent local training or testing requirements. Most activities include either one or two vessels and may last from a few hours up to 2 weeks. Vessel movement as part of the Proposed Action would be widely dispersed throughout the Study Area, but more concentrated in portions of the MITT Study Area near ports, naval installations, range complexes and testing ranges.

Minor strikes may cause temporary reversible impacts, such as diverting the turtle from its previous activity or causing minor injury. Major strikes are those that can cause permanent injury or death from bleeding or other trauma, paralysis and subsequent drowning, infection, or inability to feed. Apart from the severity of the physical strike, the likelihood and rate of a turtle's recovery from a strike may be influenced by its age, reproductive state, and general condition. Much of what is written about recovery from vessel strikes is inferred from observing individuals some time after a strike. Numerous sea turtles bear scars that appear to have been caused by propeller cuts or collisions with vessel hulls (Hazel et al. 2007; Lutcavage et al. 1997; Lutcavage and Lutz 1997), suggesting that not all vessel strikes are lethal. Conversely, fresh wounds on some stranded animals may strongly suggest a vessel strike as the cause of death. The actual incidence of recovery versus death is not known, given available data.

Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open ocean and coastal areas, whether feeding or periodically surfacing to breathe. Sea turtles spend a majority of their time submerged (Renaud and Carpenter 1994; Sasso and Witzell 2006), though Hazel (2009) showed turtles staying within the top 3 m of water despite deeper water being available. Leatherback turtles are more likely to feed at or near the surface in open ocean areas. It is important to note that leatherbacks can forage for jellyfish at depth but bring them to the surface to ingest (James and Herman 2001, Benson et al. 2011, Fossette et al. 2007). Green, hawksbill, and loggerhead turtles are more likely to forage nearshore, and although they may feed along the seafloor, they surface periodically to breathe while feeding and moving between nearshore habitats. Olive ridleys can spend extended periods foraging at depth, even in open ocean areas (McMahon et al. 2007). Green and hawksbill sea turtles are the two most common sea turtles found in the nearshore environment of the Study Area. All sea turtle species are distributed widely in all offshore portions of the Study Area.

To assess the risk or probability of a physical strike, the number, size, and speed of Navy vessels were considered, as well as the sensory capability of sea turtles to identify an approaching vessel. Because of the wide dispersal of large vessels in open ocean areas and the widespread, scattered distribution of turtles at sea, strikes during open-ocean transits of Navy vessels are unlikely. For very large vessels, the bow wave may even preclude a sea turtle strike. The probability of a strike is further reduced by Navy mitigation measures and standard operating procedures to avoid sea turtles (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring), which include lookouts and "safe speed" procedures. Smaller, faster vessels that operate in nearshore waters, where green, hawksbill, olive ridley, and loggerhead sea turtles can be more densely concentrated, pose a greater risk (Chaloupka et al. 2008b), though the density of turtles in these areas remains low. Some vessels associated with training and testing can travel at high speeds, which increase the strike risk to sea turtles (Table 3.0-15) (Hazel et al. 2007). Vessels transiting in shallow waters to and from ports travel at slower speed and pose less risk of strikes to sea turtles (see Section 3.0.5.2.3, Physical Disturbance and Strike Stressors).

3.5.3.3.1.1 No Action Alternative, Alternative 1, and Alternative 2

Training Activities

As indicated in Section 3.0.5.2.3 (Physical Disturbance and Strike Stressors), the majority of the training activities under all alternatives involve vessels. See Table 3.0-15 for a representative list of Navy vessel sizes and speeds. Vessel activities could be widely dispersed throughout the Study Area, but would be more concentrated near naval ports, piers and range areas. There would be a higher likelihood of vessel strikes over nearshore than in the open ocean portions of the MITT Study Area because of the concentration of vessel movements in those areas. Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area. Given the concentration of Navy vessel movements near naval ports, piers and range areas, this training activity could overlap with sea turtles occupying these waters.

Under the No Action Alternative, Alternative 1 and Alternative 2, exposure to vessels used in training activities may cause short-term disturbance to an individual turtle, and if struck, it could lead to injury or death. As demonstrated by scars on all species of sea turtles, they are not always able to avoid being struck; therefore, vessel strikes are a potential cause of mortality for these species.

Because of the wide dispersal of large vessels in open ocean areas and the widespread, scattered distribution of turtles at sea, strikes during open-ocean transits of Navy vessels are unlikely. For very large vessels, the bow wave may even preclude a sea turtle strike. The probability of a strike anywhere in the MITT Study Area is further reduced by Navy mitigation measures and standard operating procedures to avoid sea turtles (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). Although the likelihood of being struck is minimal, sea turtles that overlap with Navy exercises are more likely to encounter vessels. Potential impacts of exposure to vessels may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment.

Amphibious vessels could contact sea turtle nesting beaches during Amphibious Assault and Amphibious Raid operations. These amphibious vessels would include MK V Special Operations Craft, Mechanized and Utility Landing Craft, Air Cushioned Landing Craft, and other boats for transporting people or equipment. Amphibious Assault and Amphibious Raid training could be conducted in the nearshore area including the surf zone up to the high tide line at Unai Chulu, Unai Babui, and Unai Dankulo, Tinian as well as Dry Dock Island in Apra Harbor, and Dadi Beach on Guam. Amphibious Raid activities could also be conducted on Rota, but are restricted to approaches via boat docks (no beach landings). In accordance with COMNAVMARIANASINST 3500.4, prior to beach landings by amphibious vehicles, known sea turtle nesting beaches are surveyed by Navy biologists for the presence of sea turtle nests no more than 6 hours prior to a landing exercise. Areas free of nests are flagged, and vehicles are directed to remain within these areas. Landing Craft Air Cushion (LCAC) landings on Tinian are scheduled for high-tide. LCACs stay on-cushion until clear of the water and within a designated Craft Landing Zone (CLZ). Within the CLZ, LCAC come off-cushion with the LCAC oriented to permit expeditious vehicle and cargo offload onto a cleared offload and vehicle traffic area. Although LCAC and expeditionary vehicle traffic typically do not leave ruts, some compaction of sand in vehicle tracks is possible. If restoration of beach topography is required it is conducted using non-mechanized methods. Additionally, Navy biologists monitor beaches during nighttime training landing exercises. If sea turtles are observed or known to be within the area, training activities are halted until all nests have been located and sea turtles have left the area. Identified nests are avoided during the night-time landing exercise.

Pursuant to the ESA, the use of vessels during training activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

As indicated in Section 3.0.5.2.3 (Physical Disturbance and Strike Stressors), most testing activities involve the use of vessels. However, the number of vessels used for testing activities is comparatively lower than the number of vessels used for training (less than 10 percent). In addition, testing often occurs jointly with training, so it is likely that the testing activity would occur on a training vessel. Vessel movement in conjunction with testing activities could be widely dispersed throughout the Study Area, but would be concentrated near naval ports, and piers. There would be a higher likelihood of vessel strikes over the nearshore portions of the MITT Study Area (most notably during the nesting/breeding season) because of the concentration of vessel movement in those areas.

Under the No Action Alternative, Alternative 1 and Alternative 2, exposure to vessels used in testing activities may cause short-term disturbance to an individual turtle and if struck, it could lead to injury or death. As demonstrated by scars on all species of sea turtles, they are not always able to avoid being struck; therefore, vessel strikes are a potential cause of mortality for these species.

Because of the wide dispersal of large vessels in open ocean areas and the widespread, scattered distribution of turtles at sea, strikes during open-ocean transits of Navy vessels are unlikely. For very large vessels, the bow wave may even preclude a sea turtle strike. The probability of a strike anywhere in the MITT Study Area is further reduced by Navy mitigation measures and standard operating procedures to avoid sea turtles (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). Although the likelihood of being struck is minimal, sea turtles that overlap with Navy activities are more likely to encounter vessels. Potential impacts of exposure to vessels may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment.

Pursuant to the ESA, the use of vessels during testing activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.3.2 Impacts from In-Water Devices

In-water devices are generally smaller (several inches to 111 ft. [33.8 m]) than most Navy vessels. For a discussion of the types of activities that use in-water devices, where they are used, and how many activities would occur under each alternative, see Section 3.0.5.2.3.3 (In-Water Devices). See Table 3.0-16 for the types, sizes, and speeds of Navy in-water devices used in the Study Area.

Devices that pose the greatest collision risk to sea turtles are those that are towed or operated at high speeds and include: remotely operated high-speed targets and mine warfare systems. Devices that move slowly through the water column have a very limited potential to strike a sea turtle because sea turtles in the water could avoid a slow-moving object.

3.5.3.3.2.1 No Action Alternative, Alternative 1, and Alternative 2

Training Activities

Use of in-water devices is concentrated to anti-submarine warfare and mine warfare activities throughout the Study Area. Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area.

Under the No Action Alternative, Alternative 1 and Alternative 2, exposure to in-water devices used in training activities may cause short-term disturbance to an individual turtle, or if struck, it could lead to injury or death. These devices can operate anywhere from the water surface to the benthic zone. Certain devices do not have a realistic potential to strike living marine resources because they either move slowly through the water column (e.g., most unmanned undersurface vehicles) or are closely monitored by observers manning the towing platform (e.g., most towed devices). Because of their size and potential operating speed, in-water devices that operate in a manner with the potential to strike living marine resources are the Unmanned Surface Vehicles. Training activities that involve the use of unmanned surface or underwater activities include Amphibious Raid activities, which occur six times a year. The possibility of a strike anywhere in the MITT Study Area is reduced by Navy mitigation measures and standard operating procedures to avoid sea turtles (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring).

Although the likelihood of being struck is minimal, sea turtles that are present during Navy exercises are more likely to encounter in-water devices. Potential impacts of exposure to in-water devices may result in changes to an individual’s behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. The impact of in-water devices on sea turtles is not likely to cause injury or mortality to individuals, and impacts to populations would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most sea turtle’s ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, and (3) exposures would be localized. Activities involving in-water devices are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of sea turtles species at the population level.

Pursuant to the ESA, the use of in-water devices during training activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under the No Action Alternative, Alternative 1 and Alternative 2, exposure to in-water devices used in testing activities may cause short-term disturbance to an individual turtle, or, if struck, it could lead to injury or death. However, these devices move slowly through the water column and have a very limited potential to strike a sea turtle because sea turtles in the water could avoid a slow moving object. Potential impacts of exposure to in-water devices may result in changes to an individual’s behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. Potential impacts of exposure to in-water devices are not expected to result in population-level impacts. There is no overlap of the stressor with any designated sea turtle critical habitat.

Pursuant to the ESA, the use of in-water devices during testing activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.3.3 Impacts from Military Expended Materials

This section analyzes the strike potential to sea turtles from the following categories of military expended materials: (1) all sizes of non-explosive practice munitions; (2) fragments from explosive munitions; and (3) expended materials other than ordnance, such as sonobuoys, ship hulks, expendable targets and unrecovered aircraft stores (fuel tanks, carriages, dispensers, racks, or similar types of support systems on aircraft).

While disturbance or strike from an item as it falls through the water column is possible, it is not very likely because the objects generally sink through the water slowly and can be avoided by most sea turtles. Therefore, the discussion of military expended materials strikes will focus on the potential of a strike at the surface of the water.

The potential for sea turtles to be struck by military expended materials was evaluated using statistical probability analysis (Appendix G, Statistical Probability Model for Estimating Direct Strike Impact and Number of Potential Exposures) to estimate the probability of striking a sea turtle for a worst-case scenario. Input values include munitions data (frequency, footprint, and type), size of the training and testing area, sea turtle density data, and size of the animal (area of potential impact). To estimate the potential to strike a sea turtle in a worst-case scenario, the impact area of all bombs and projectiles was totaled over 1 year in the training or testing area for each alternative with the highest projected use (concentration of military expended materials). Finally, the sea turtle species with the highest average seasonal density within the activity at each location was used.

The estimate of the potential for a sea turtle strike is influenced by the following assumptions:

- The estimate assumes that all sea turtles would be at or near the surface 100 percent of the time (two-dimensional), when in fact, sea turtles spend most of their time submerged (Renaud and Carpenter 1994; Sasso and Witzell 2006).
- That the animal is stationary and does not account for any movement of the sea turtle or any potential avoidance of the training or testing activity.

The model does not account for the ability of Navy observers to see and avoid sea turtles. The model also does not account for the fact that most of the projectiles fired during training and testing activities are fired at targets, and most projectiles hit those targets, so only a very small portion of those would hit the water with their maximum velocity and force. The potential of fragments from high-explosive munitions or expended material other than ordnance to strike a sea turtle is likely lower than for the worst-case scenario calculated below because those activities happen with much lower frequency. Fragments may include metallic fragments from the exploded target as well as from the exploded ordnance.

There is a remote possibility that an individual turtle at or near the surface may be struck directly if they are in the target area at the point of physical impact at the time of non explosive ordnance delivery. Expended munitions may strike the water surface with sufficient force to cause injury or mortality. While any species of sea turtle may move through the open ocean, most will only surface intermittently. Sea turtles are generally at the surface for short periods, and spend most of their time submerged

(Renaud and Carpenter 1994; Sasso and Witzell 2006). The leatherback turtle is more likely to be foraging at or near the surface in the open ocean than other species, but the likelihood of being struck by a projectile remains very low (Table 3.5-11).

Table 3.5-11: Estimated Sea Turtle Exposures from Direct Strike of Military Expended Materials by Area and Alternative

Mariana Islands Training and Testing Study Area						
Nearshore Area (MITT Study Area shallower than 200 m)						
Species	Training			Testing		
	No Action	Alternative 1	Alternative 2	No Action	Alternative 1	Alternative 2
Green Sea Turtle	0.00092	0.00231	0.00231	0.00001	0.00005	0.00005
Hawksbill Sea Turtle	0.00005	0.00014	0.00014	< 0.00001	< 0.00001	< 0.00001
Loggerhead Sea Turtle	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Olive Ridley Sea Turtle	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Leatherback Sea Turtle	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Open Ocean (MITT Study Area deeper than 200 m)						
Species	Training			Testing		
	No Action	Alternative 1	Alternative 2	No Action	Alternative 1	Alternative 2
All Turtle Species	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001

Notes: m = meter(s), MITT = Mariana Islands Training and Testing

The probability of a strike is further reduced by Navy mitigation measures and standard operating procedures to avoid sea turtles (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring).

3.5.3.3.3.1 No Action Alternative, Alternative 1, and Alternative 2

As described in Section 2.7, Alternative 1 consists of the No Action Alternative, plus the expansion of MITT Study Area boundaries and adjustments to location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As described in Section 2.8, Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities.

Training Activities

With the exception of those used at FDM, the majority of military expended materials (bombs, medium- and large-caliber projectiles, missiles, and decelerators/parachutes) are all used in areas of the MITT Study Area greater than 3 nm from shorelines, and the larger of these (bombs, missiles, large-caliber projectiles) are restricted to use in areas greater than 3 nm from shore. Small caliber projectiles would be used throughout the MITT Study Area. Table 3.5-11 presents the strike probabilities for each species of sea turtles, which are very small. The probabilities of a strike in the open ocean portion of the MITT Study Area, where the majority of materials are expended, is less than 0.00001 percent for all species of sea turtles.

Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area. Under the No Action Alternative, Alternative 1, and Alternative 2 exposures to military-expended materials used in training activities may cause short-term disturbance to an individual turtle, or, if struck, it could lead to injury or death. Potential impacts of exposure to military-expended materials may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. Potential impacts of exposure to military-expended materials are not expected to result in population-level impacts.

With regards to military expended material used at FDM, there is a very low potential for aberrant ordnance to impact the nearshore waters surrounding land-based targets. The probability of direct strike in nearshore and offshore waters on sea turtles were calculated for areas where ordnance is targeted (expected to fall), and probabilities of strike were calculated to be near zero percent. Based on this calculation, it is even more unlikely for a direct strike on a sea turtle or marine mammal from aberrant ordnance at FDM.

Pursuant to the ESA, the use military expended materials during training activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

As indicated in Tables 2.8-2 through 2.8-4, there are no activities which would generate military expended materials in the MITT Study Area under the No Action Alternative.

Under Alternative 1 and 2, activities that could generate military expended materials would increase, and could take place throughout the Study Area. Similar to those for training activities, consequences of strikes or disturbances could include injury or mortality, particularly within the footprint of the object. Table 3.5-11 presents the strike probabilities for each species of sea turtles. The probabilities of a strike in the open ocean portion of the MITT Study Area, where the majority of materials are expended, is less than 0.00001 percent for all species of sea turtles.

Under Alternative 1 and Alternative 2, exposures to military expended materials used in testing activities may cause short-term disturbance to an individual turtle, or if struck, it could lead to injury or death. Potential impacts of exposure to military expended materials may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. The fitness of individual organisms could be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the possibility of strike is so low.

Pursuant to the ESA, the use military expended materials during testing activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.3.4 Impacts from Seafloor Devices

For a discussion of the types of activities that use seafloor devices, where they are used, and how many activities would occur under each alternative, see Section 3.0.5.2.3.5 (Seafloor Devices). These include items that are placed on, dropped on, or moved along the seafloor such as mine shapes, anchor blocks, anchors, bottom-placed instruments, bottom-crawling unmanned undersea vehicles, and bottom-placed targets that are recovered (not expended). As discussed in Section 3.5.3.3.3 (Impacts from Military Expended Materials), objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most sea turtles.

3.5.3.3.4.1 No Action Alternative

Training Activities

Table 3.0-21 lists the number and location where seafloor devices are used. Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area.

Under the No Action Alternative, exposure to seafloor devices used in training activities may cause short-term disturbance to an individual turtle because if a sea turtle were struck, it could lead to injury or death. However, objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most sea turtles. Further, the potential for a sea turtle to be close to a seafloor device, and therefore be exposed, is very low, though if foraging along the bottom, exposure to a seafloor device could occur. However, the slow speed of these devices would minimize the potential impact from exposure. Exposure to seafloor devices is not expected to change an individual's behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness). Exposure to seafloor devices is not expected to result in population-level impacts.

Pursuant to the ESA, the use of seafloor devices during training activities as described under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtle.

Testing Activities

Table 3.0-21 lists the number and location where seafloor devices are used. Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area.

Under the No Action Alternative, exposure to seafloor devices used in testing activities may cause short-term disturbance to an individual turtle, or if a sea turtle were struck, it could lead to injury or death. However, objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most sea turtles. Furthermore, the potential for a sea turtle to be close to a seafloor device, and therefore to be exposed, is very low, though if foraging along the bottom, exposure to a seafloor device could occur. However, the slow speed of these devices would minimize the potential impact from exposure. Exposure to seafloor devices is not expected to change an individual's behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness). Exposure to seafloor devices is not expected to result in population-level impacts.

Pursuant to the ESA, the use of seafloor devices during testing activities as described under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles.

3.5.3.3.4.2 Alternative 1

Training Activities

Table 3.0-21 lists the number and location where seafloor devices are used. Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area.

Under Alternative 1, exposure to seafloor devices used in training activities may cause short-term disturbance to an individual turtle because if a sea turtle were struck, it could lead to injury or death. However, objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most sea turtles. Furthermore, the potential for a sea turtle to be close to a seafloor device, and therefore to be exposed, is very low, because of the relative position of sea turtles within the water column and the wide distribution of habitats. Exposure to seafloor devices is not expected to change an individual's behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness). Exposure to seafloor devices is not expected to result in population-level impacts.

Pursuant to the ESA, the use of seafloor devices during training activities as described under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles.

Testing Activities

The number and location of testing activities under Alternative 1 increases when compared to No Action Alternative (Table 3.0-21). Under Alternative 1, exposure to seafloor devices used in testing activities may cause short-term disturbance to an individual turtle, or if a sea turtle were struck, it could lead to injury or death. However, objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most sea turtles. Furthermore, the potential for a sea turtle to be close to a seafloor device, and therefore to be exposed, is very low, because of the relative position of sea turtles within the water column and the wide distribution of habitats. Exposure to seafloor devices is not expected to change an individual's behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness). Exposure to seafloor devices is not expected to result in population-level impacts.

Pursuant to the ESA, the use of seafloor devices during testing activities as described under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles.

3.5.3.3.4.3 Alternative 2

Training Activities

The number and location of training activities under Alternative 2 are identical to those of the training activities under Alternative 1. Therefore, impacts and comparisons to the No Action Alternative would also be identical, as described in Section 3.5.3.3.4.2 (Alternative 1).

Pursuant to the ESA, the use of seafloor devices during training activities as described under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles.

Testing Activities

Table 3.0-21 lists the number and location where seafloor devices are used. The number and location of testing activities under Alternative 2 increases slightly (from 64 to 68 events) to those of the testing activities under the Alternative 1. Although the number of events utilizing seafloor devices increases, the potential for a sea turtle to be close to a seafloor device, and therefore to be exposed, remains very low, because of the relative position of sea turtles within the water column and the wide distribution of habitats. Exposure to seafloor devices is not expected to change an individual's behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness). Exposure to seafloor devices is not expected to result in population-level impacts.

Pursuant to the ESA, the use of seafloor devices during testing activities as described under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles.

3.5.3.4 Entanglement Stressors

This section analyzes the potential entanglement impacts of the various types of expended materials used by the Navy during training and testing activities within the Study Area. This analysis includes the potential impacts from two types of military expended materials, including: (1) fiber optic cables and guidance wires, and (2) decelerators/parachutes. Aspects of entanglement stressors that are applicable to marine organisms in general are presented in Appendix H (Biological Resource Methods).

3.5.3.4.1 Impacts from Fiber Optic Cables and Guidance Wires

Fiber optic cables and guidance wires are used in several different training and testing activities. For a list of Navy activities that involve the use of fiber optic cables and wires, refer to Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires). A sea turtle that becomes entangled in nets, lines, ropes, or other foreign objects under water may suffer only a temporary hindrance to movement before it frees itself. The turtle may suffer minor injuries but recover fully, or it may die as a result of the entanglement. Due to the physical characteristics of guidance wires and fiber optic cables detailed in Section 3.0.5.2.4 (Entanglement Stressors), these items pose a potential, although unlikely, entanglement risk to sea turtles.

The likelihood of a sea turtle encountering and becoming entangled in a fiber optic cable or guidance wire depends on several factors. The length of time that the fiber optic cable or guidance wire is near a sea turtle can affect the likelihood of it posing an entanglement risk. Because these items would only be in the water column during the activity and while it sinks, the likelihood of a sea turtle encountering a fiber optic cable in the water column and becoming entangled is extremely low. Guidance wires sink to the sea floor at a rate of 0.7 ft. (0.2 m) per second; therefore, it is most likely that a sea turtle would encounter a guidance wire once it had settled to the sea floor. The length of the cable or wire may influence the potential for a sea turtle to encounter or become entangled in these items. The lengths of fiber optic cables and guidance wires vary. Fiber optic cables can range in size up to about 900 ft. (300 m). Greater lengths of these items may increase the likelihood that a sea turtle could become entangled. The behavior and feeding strategy of a species can also determine whether they may encounter items on the seafloor, where fiber optic cables and guidance wires will most likely be available. There is a potential for those species that feed on the seafloor to encounter these items and become entangled; however, the relatively few fiber optic cables and guidance wires being expended within the MITT Study Area limits the potential for encounters. Lastly, the properties of the items themselves may limit the risk of entanglement. The physical characteristics of guidance wires and fiber optic cables are detailed in Section 3.0.5.2.4 (Entanglement Stressors). This analysis indicates that these items pose a potential, although unlikely, entanglement risk to sea turtles. For instance, the physical characteristics of the fiber optic material render the cable brittle and easily broken when kinked, twisted, or bent sharply (i.e., to a radius greater than 360 degrees). Thus, the fiber optic cable would not loop, greatly reducing or eliminating any potential issues of entanglement with regard to marine life. In addition, based on degradation times, the guidance wires would break down within 1–2 years and therefore no longer pose an entanglement risk.

The Navy previously analyzed the potential for entanglement of sea turtles by guidance wires and concluded that the potential for entanglement is low (U.S. Department of the Navy 1996). Except for a chance encounter with the guidance wire at the surface or in the water column while the cable or wire is sinking to the seafloor, a sea turtle would be vulnerable to entanglement only if its diving and feeding patterns place it in direct contact with the bottom. Bottom-feeding sea turtles tend to forage in nearshore areas, and these wires are expended in deeper waters.

3.5.3.4.1.1 No Action Alternative

Training Activities

As indicated in Chapter 2 (Description of Proposed Action and Alternatives), under the No Action Alternative, there are no Airborne mine neutralization activities (with explosive neutralizers) that expend fiber optic cables (Table 3.0-23) and 40 guidance wires expended from torpedoes (Table 3.0-24). Torpedoes expending guidance wire would occur in throughout the MITT Study Area during tracking exercises, all greater than 3 nm from the shore, where depths are greater than the diving abilities of sea turtles.

Any species of sea turtle that occurs in the MITT Study Area could at some point in time encounter expended cables or wires. The sink rates of fiber optic cables and guidance wires would rule out the possibility of them drifting great distances into nearshore and coastal areas where green, hawksbill, olive ridley, and loggerhead turtles are more likely to occur and feed on the bottom. The leatherback is more likely to co-occur with these activities, given its preference for open ocean habitats, but this species is known to forage on jellyfish at or near the surface.

Under the No Action Alternative, exposure to fiber optic cables and guidance wires used in training activities may cause short-term or long-term disturbance to an individual turtle because if a sea turtle were to become entangled in a fiber optic cable or guidance wire, it could free itself or it could lead to injury or death. Potential impacts of exposure to fiber optic cable or guidance wire may result in changes to an individual’s behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, cables and wires are generally not expected to cause disturbance to sea turtles because: (1) the number of fiber optic cables and guidance wires expended is relatively low, decreasing the likelihood of encounter; (2) the physical characteristics of the fiber optic cables and guidance wires; and (3) the behavior of the species, as sea turtles are unlikely to become entangled in an object that is resting on the seafloor. Potential impacts of exposure to fiber optic cables and guidance wires are not expected to result in population-level impacts.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during training activities as proposed under the No Action Alternative may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under the No Action Alternative, no testing activities that could generate entanglement stressors are conducted in the Study Area.

3.5.3.4.1.2 Alternative 1

Training Activities

As indicated in Table 2.8-1 and Table 3.0-24, under Alternative 1, the number of torpedo activities that expended guidance wire is the same as the No Action Alternative. The torpedo activities using guidance wire under Alternative 1 would occur in the same geographic locations as the No Action Alternative. There would also be four fiber optic cables expended under Alternative 1 (Table 3.0-23).

Any species of sea turtle that occurs in the MITT Study Area could at some point in time encounter expended fiber optic cables or guidance wires. The sink rates of fiber optic cables and guidance wires would rule out the possibility of them drifting great distances into nearshore and coastal areas where green, hawksbill, olive ridley, and loggerhead turtles are more likely to occur and feed on the bottom. The leatherback is more likely to co-occur with these activities, given its preference for open ocean habitats, but this species is known to forage on jellyfish at or near the surface.

In comparison to the No Action Alternative, the increase in activities presented in Alternative 1 may increase the risk of sea turtles being exposed to fiber optic cables and guidance wires. However, the expected impact on any exposed sea turtle remains the same. For the same reasons as stated in Section 3.5.3.4.1.1 (No Action Alternative), the use of fiber optic cables and guidance wires in training activities may cause short-term or long-term disturbance to an individual turtle, because if a sea turtle were to become entangled in a fiber optic cable or guidance wire, it could free itself or it could lead to injury or death. Potential impacts of exposure to fiber optic cable or guidance wire may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. Potential impacts of exposure to fiber optic cables and guidance wires are not expected to result in population-level impacts.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during training activities as proposed under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

As indicated in Tables 2.8-2 through 2.8-4 and Table 3.0-24, under Alternative 1, the number of torpedo activities that expended guidance wire increases from that of the No Action Alternative from 0 to 20. Under Alternative 1, MCM mission package testing (Table 3.0-23) expends up to 48 fiber optic cables.

Any species of sea turtle that occurs in the MITT Study Area could at some point in time encounter expended fiber optic cables or guidance wires. The sink rates of fiber optic cables and guidance wires would rule out the possibility of them drifting great distances into nearshore and coastal areas where green, hawksbill, olive ridley, and loggerhead turtles are more likely to occur and feed on the bottom. The leatherback is more likely to co-occur with these activities, given its preference for open ocean habitats, but this species is known to forage on jellyfish at or near the surface.

Exposure to fiber optic cables and guidance wires used in testing activities may cause short-term or long-term disturbance to an individual turtle because if a sea turtle were to become entangled in a fiber optic cables and guidance wire, it could free itself or it could become injured or die. Potential impacts of exposure to fiber optic cables and guidance wire may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, fiber optic cables and guidance wires are generally not expected to cause disturbance to sea turtles because: (1) the number of fiber optic cables and guidance wires expended is relatively low, decreasing the likelihood of encounter; (2) the physical characteristics of the fiber optic cables and guidance wires; and (3) the behavior of the species, as sea turtles are unlikely to become entangled in an object that is resting on the seafloor. Potential impacts of exposure to fiber optic cables and guidance wires are not expected to result in population-level impacts.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during testing activities as proposed under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.4.1.3 Alternative 2

Training Activities

Activities proposed under Alternative 2 are the same as those proposed under Alternative 1. Therefore, the impact conclusion for Alternative 2 training activities is the same as for Alternative 1.

The entanglement of sea turtles by fiber optic cables or guidance wires is considered to be highly unlikely. If a sea turtle became entangled in a cable, however, the sea turtle would suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) could indirectly result in mortality while impairment of other activities (e.g., migration) could affect reproduction.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during training activities as proposed under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

As indicated in Table 2.8-2 through 2.8-4 and Table 3.0-24, under Alternative 1, the number of torpedo activities that expended guidance wire increases from that of the No Action Alternative from 0 to 20. Under Alternative 2, MCM mission package testing (Table 3.0-23) expends up to 56 fiber optic cables.

Any species of sea turtle that occurs in the MITT Study Area could at some point in time encounter expended by fiber optic cables or guidance wires. The sink rates of guidance wires would rule out the possibility of them drifting great distances into nearshore and coastal areas where green, hawksbill, olive ridley, and loggerhead turtles are more likely to occur and feed on the bottom. The leatherback is more likely to co-occur with these activities, given its preference for open ocean habitats, but this species is known to forage on jellyfish at or near the surface.

The entanglement of sea turtles by fiber optic cables or guidance wires is considered to be highly unlikely. If a sea turtle became entangled in a by fiber optic cables or guidance wire however, the sea turtle would suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) could indirectly result in mortality while impairment of other activities (e.g., migration) could affect reproduction.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during testing activities as proposed under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.4.2 Impacts from Decelerators/Parachutes

Sonobuoys, lightweight torpedoes, targets, and other devices deployed by aircraft into the water use nylon decelerators/parachutes of various sizes. For example, a typical sonobuoy decelerator/parachute is about 18 in. (0.46 m) in diameter, with nylon suspension lines about 2 ft. (0.61 m) long. These decelerators/parachutes are not typically recovered after the activity (Appendix A, Training and Testing Activities Descriptions). Once a sonobuoy hits the water surface, its decelerator/parachute is designed to produce drag at the surface for 5 to 15 seconds, allowing for deployment of the sonobuoy, then the decelerator/parachute separates and sinks. The decelerator/parachute assembly contains metallic components, and could be at the surface for a short period before sinking to the seafloor. Sonobuoy decelerators/parachutes are designed to sink within 15 minutes, but the rate of sinking depends upon sea conditions and the shape of the decelerator/parachute and the duration of the descent would depend on the water depth. Prior to reaching the seafloor, it could be carried along in a current, or snagged on a hard structure near the bottom. Conversely, it could settle to the bottom, where it would be buried by sediment in most soft bottom areas. Decelerators/parachutes or decelerator/parachute lines may be a risk for sea turtles to become entangled, particularly while at the surface. A sea turtle would have to surface to breathe or grab prey from under the decelerator/parachute, and swim into the decelerator/parachute or its lines.

While in the water column, a sea turtle is less likely to become entangled because the decelerator/parachute would have to land directly on the turtle, or the turtle would have to swim into the decelerator/parachute before it sank. If the decelerator/parachute and its lines sink to the seafloor in an area where the bottom is calm, it would remain there undisturbed. Over time, it may become covered by sediment in most areas or colonized by attaching and encrusting organisms, which would further stabilize the material and reduce the potential for reintroduction as an entanglement risk.

If bottom currents are present, the canopy may billow and pose an entanglement threat to sea turtles that feed in benthic habitats (e.g., loggerhead sea turtles). Bottom-feeding sea turtles tend to forage in nearshore areas rather than offshore, where these decelerators/parachutes are used; therefore, sea turtles are not likely to encounter decelerators/parachutes once they reach the seafloor. Further, the deposition of a decelerator/parachute on the seafloor would occur in water depths that are greater than the diving abilities (and hence foraging abilities) of sea turtles. The potential for a sea turtle to encounter an expended decelerator/parachute at the surface or in the water column is extremely low, and is even less probable at the seafloor, given the general improbability of a sea turtle being near the deployed decelerator/parachute, as well as the general behavior of sea turtles.

3.5.3.4.2.1 No Action Alternative

<u>Training Activities</u>

Under the No Action Alternative, activities that involve air-dropped sonobuoys, torpedoes, or targets (and therefore the expending of unrecoverable decelerators/parachutes) include tracking and torpedo exercises involving helicopter platforms and fixed-wing aircraft. Under the No Action Alternative, approximately 8,032 decelerators/parachutes are expended during training activities (see Table 3.0-25). Decelerators/parachutes associated with training activities would be expended in the following locations in areas greater than 3 nm from shore throughout the Study Area. Activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600 ft.).

These exercises are widely dispersed in open ocean habitats, however, where sea turtles are lower in abundance than in nearshore habitats. Furthermore, entanglement of a sea turtle in a decelerator/parachute assembly is unlikely because the decelerator/parachute would have to land directly on a sea turtle, or a sea turtle would have to swim into it before it settles to the ocean floor, or the sea turtle would have to encounter the decelerator/parachute on the ocean floor. The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands, and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). If bottom currents are present, the canopy could billow and pose an entanglement threat to bottom-feeding sea turtles. However, the probability of a sea turtle encountering a decelerator/parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines are both considered low.

The entanglement of sea turtles in decelerator/parachute assemblies is considered to be highly unlikely. If a sea turtle became entangled in a decelerator/parachute assembly, however, the sea turtle may suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) may indirectly result in mortality while impairment of other activities (e.g., migration) may impair reproduction.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as proposed under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under the No Action Alternative, no activities that would create entanglement hazards from decelerators/parachutes are conducted in the Study Area.

3.5.3.4.2.2 Alternative 1

Training Activities

Under Alternative 1, approximately 10,845 decelerators/parachutes would be expended during training activities, an increase from the number expended under the No Action Alternative (see Table 3.0-25). Decelerators/parachutes associated with these sonobuoys would be expended in the following locations in areas greater than 3 nm from shore throughout the Study Area. Similar to the No Action Alternative, activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600 ft.). Because they are in the air and water column for a time span of minutes it is improbable that such a decelerator/parachute deployed over water deeper than 183 m (600.4 ft.) could travel far enough to affect shallow-water areas.

The net increase in exercises that would expend decelerators/parachutes would increase the risk of entangling sea turtles. These exercises are widely dispersed in open ocean habitats, however, where sea turtles are lower in abundance than in nearshore habitats. Furthermore, entanglement of a sea turtle in a decelerator/parachute assembly is unlikely because the decelerator/parachute would have to land directly on a sea turtle, or a sea turtle would have to swim into it before it settles to the ocean floor, or the sea turtle would have to encounter the decelerator/parachute on the ocean floor. The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands (anywhere within the approximately 500,000 square nautical miles [nm^2] of the MITT Study Area), and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands, and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). If bottom currents are present, the canopy could billow and pose an entanglement threat to bottom-feeding sea turtles. However, the probability of a sea turtle encountering a decelerator/parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines are both considered low.

The entanglement of sea turtles in decelerator/parachute assemblies is considered to be highly unlikely. If a sea turtle became entangled in a decelerator/parachute assembly, however, the sea turtle would suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) could indirectly result in mortality while impairment of other activities (e.g., migration) could impair reproduction.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as proposed under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under Alternative 1, approximately 1,727 decelerators/parachutes would be expended during testing activities, an increase from the number expended under the No Action Alternative (see Table 3.0-25). These decelerators/parachutes would be expended in areas greater than 3 nm from shore throughout the Study Area. Similar to the training activities, activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600.4 ft.). Because they are in the air and water column for a time span of minutes it is improbable that such a decelerator/parachute deployed over water deeper than 183 m (600.4 ft.) could travel far enough to affect shallow-water areas.

The net increase in exercises that would expend decelerators/parachutes would increase the risk of entangling sea turtles. These exercises are widely dispersed in open ocean habitats, however, where sea turtles are lower in abundance than in nearshore habitats. Furthermore, entanglement of a sea turtle in a decelerator/parachute assembly is unlikely because the decelerator/parachute would have to land directly on a sea turtle, or a sea turtle would have to swim into it before it settles to the ocean floor, or the sea turtle would have to encounter the decelerator/parachute on the ocean floor. The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands (anywhere within the approximately 500,000 nm^2 of the MITT Study Area), and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands, and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). If bottom currents are present, the canopy could billow and pose an entanglement threat to bottom-feeding sea turtles. However, the probability of a sea turtle encountering a decelerator/parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines are both considered low.

The entanglement of sea turtles in decelerator/parachute assemblies is considered to be highly unlikely. If a sea turtle became entangled in a decelerator/parachute assembly, however, the sea turtle could suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) could indirectly result in mortality while impairment of other activities (e.g., migration) could impair reproduction.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities as proposed under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.4.2.3 Alternative 2

Training Activities

Alternative 2 training activities would use the same number of decelerators/parachutes as are proposed under Alternative 1; therefore, the conclusions for decelerator/parachute use under Alternative 2 are the same as under Alternative 1.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as proposed under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under Alternative 2, approximately 1,912 decelerators/parachutes would be expended during testing activities, an increase from the number expended under the No Action Alternative (see Table 3.0-25). These decelerators/parachutes would be expended in areas greater than 3 nm from shore throughout the Study Area. Similar to the Alternative 1 activities, activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600.4 ft.). Because they are in the air and water column for a time span of minutes it is improbable that such a decelerator/parachute deployed greater than 3 nm from shore could travel far enough to affect shallow-water areas.

The net increase in exercises that would expend decelerators/parachutes would increase the risk of entangling sea turtles. These exercises are widely dispersed in open ocean habitats, however, where sea turtles are lower in abundance than in nearshore habitats. Furthermore, entanglement of a sea turtle in a decelerator/parachute assembly is unlikely because the decelerator/parachute would have to land directly on a sea turtle, or a sea turtle would have to swim into it before it settles to the ocean floor, or the sea turtle would have to encounter the decelerator/parachute on the ocean floor. The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands (anywhere within the approximately 500,000 nm^2 of the MITT Study Area), and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). If bottom currents are present, the canopy could billow and pose an entanglement threat to bottom-feeding sea turtles. However, the probability of a sea turtle encountering a decelerator/parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines are both considered low.

The entanglement of sea turtles in decelerator/parachute assemblies is considered to be highly unlikely. If a sea turtle became entangled in a decelerator/parachute assembly, however, the sea turtle could suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) could indirectly result in mortality while impairment of other activities (e.g., migration) could impair reproduction.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities as proposed under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.5 Ingestion Stressors

This section analyzes the potential ingestion impacts of the various types of expended materials used by the Navy during training and testing activities within the Study Area. This analysis includes two categories of military expended materials: (1) munitions (both non-explosive practice munitions and fragments from high-explosive munitions), which are expected to sink to the seafloor; and (2) military expended materials other than munitions (including fragments from targets, chaff, flares, and parachutes), which may remain at the surface or in the water column for some time prior to sinking.

Ingestion of expended materials by sea turtles could occur in all nearshore and open ocean areas, and can occur at the surface, in the water column, or at the seafloor depending on the size and buoyancy of the expended object and the feeding behavior of the turtle. Floating material could be eaten by turtles such as leatherbacks that feed at or near the water surface, while materials that sink to the seafloor pose a risk to bottom-feeding turtles such as loggerheads. Schuyler et al. (2012) observed that carapace length was inversely correlated with the probability of ingesting debris in green and hawksbill sea turtles; 54.5 percent of pelagic sized turtles had ingested debris, whereas only 25 percent of benthic feeding turtles were found with debris in their gastrointestinal system. Benthic phase turtles had a strong selectivity for soft, clear plastic, lending support to the hypothesis that sea turtles ingest debris because it resembles natural prey items such as jellyfish. Pelagic turtles were much less selective in their feeding, though they showed a trend towards selectivity for rubber items such as balloons. Most ingested items were plastic and were positively buoyant.

Leatherbacks feed primarily on jellyfish throughout the water column, and may mistake floating debris for prey. Items found in a sample of leatherbacks that had ingested plastic included plastic bags, fishing line, twine, Mylar balloon fragments, and a plastic spoon (Mrosovsky et al. 2009). Kemp's ridleys, loggerheads, and green sea turtles in coastal Florida were found to ingest bits of plastic, tar, rubber, and aluminum foil (Bjorndal et al. 1994). Oceanic-stage loggerhead turtles in the North Atlantic Ocean were found to ingest "small pieces of hard plastic," corks, and white Styrofoam pieces (Frick et al. 2009). Juvenile loggerheads in the Mediterranean ingested plastic most frequently, followed by tar, Styrofoam, wood, feathers, lines, and net fragments (Tomas et al. 2002). Similar trends in types of items ingested were observed in Kemp's ridley, loggerhead, and green sea turtles off the Texas coast (Stanley et al. 1988). Conditions for marine pollution in the Pacific are similar to conditions in the Atlantic, Mediterranean, and the Gulf of Mexico; therefore, sea turtle ingestion rates of non-prey items in the Pacific is expected to be similar to other sea turtle habitats. The variety of items ingested by turtles suggests that feeding is nondiscriminatory, and they are prone to ingesting nonprey items. Ingestion of these items may not be directly lethal; however, ingestion of plastic and other fragments can restrict food intake and have sub-lethal impacts by reducing nutrient intake (McCauley and Bjorndal 1999). Poor nutrient uptake can lead to decreased growth rates, depleted energy, reduced reproduction, and decreased survivorship. These long-term sublethal effects may lead to population level impacts, but this is difficult to assess because the affected individuals remain at sea and the trends may only arise after several generations have passed.

Because bottom-feeding occurs in nearshore areas, materials that sink to the seafloor in the open ocean are less likely to be ingested due to their location, as depth in areas where ordnance is fired ranges from approximately 20 to 200 m (65.6 to 656.2 ft.) in areas far offshore. The consequences of ingestion could range from temporary and inconsequential to long-term physical stress, or even death.

3.5.3.5.1 Impacts from Munitions

Types of non-explosive practice munitions generally include projectiles, missiles, and bombs. Of these, only small or medium caliber projectiles would be small enough for a sea turtle to ingest. Small and medium caliber projectiles include all sizes up to and including 2.25 in. (5.7 cm) in diameter. These solid metal materials would quickly move through the water column and settle to the seafloor. Ingestion of non-explosive practice munitions is not expected to occur in the water column because the ordnance sinks quickly. Instead, they are most likely to be encountered by species that forage on the bottom. The types, numbers, and locations of activities using these devices under each alternative are discussed in Sections 3.0.5.2.5.1 (Non-Explosive Practice Munitions) and 3.0.5.2.5.2 (Fragments from Explosive Munitions). Because green, loggerhead, olive ridley, and hawksbill turtles feed along the seafloor, they are more likely to encounter munitions of ingestible size that settle on the bottom than leatherbacks that primarily feed at the surface. Furthermore, these four species typically use nearshore feeding areas, while leatherbacks are more likely to feed in the open ocean. Given the very low probability of a leatherback encountering and ingesting materials on the seafloor, this analysis will focus on green, loggerhead, olive ridley, and hawksbill turtles and ingestible materials expended nearshore, within range complexes and testing ranges.

3.5.3.5.1.1 No Action Alternative

Training Activities

The number and footprint of small- and medium-caliber projectiles (the only ingestible sizes) are detailed in Table 2.8-1. Any bottom-feeding sea turtle may occur in these range complexes. The number and footprint of high-explosive ordnance and munitions are detailed in Table 2.8-1; however, the fragment size cannot be quantified. The areas with the greatest amount of high-explosive ordnance and munitions would occur in open ocean portions the Study Area.

Sublethal effects due to ingestion of munitions used in training activities may cause short-term or long-term disturbance to an individual turtle because: (1) if a sea turtle were to incidentally ingest and swallow a projectile or solid metal high-explosive fragment, it could potentially disrupt its feeding behavior or digestive processes; and (2) if the item is particularly large in proportion to the turtle ingesting it, the projectile could become permanently encapsulated by the stomach lining, with a rare chance that this could impede the turtle's ability to feed or take in nutrients. Potential impacts of exposure to munitions may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, munitions used in training activities are generally not expected to cause disturbance to sea turtles because: (1) sea turtles are not expected to encounter most small- and medium-caliber projectiles or high-explosive fragments on the seafloor because of the depth at which these would be expended; and (2) in some cases a turtle would likely pass the projectile through their digestive tract and expel the item without impacting the individual. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the use of munitions of ingestible size during training activities under the No Action Alternative would have no affect leatherback sea turtles. The use of munitions of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

Testing Activities

Under the No Action Alternative, no activities utilizing small- or medium-caliber projectiles or high explosive ordnance are conducted in the Study Area.

3.5.3.5.1.2 Alternative 1

Training Activities

Under Alternative 1, the amount of small- and medium-caliber projectiles approximately doubles that of the No Action Alternative, from 86,500 to 171,640 projectiles (see Table 3.0-18). The number of activities that use high-explosive ordnance and munitions increases from 1,340 under the No Action Alternative to 10,006 under Alternative 1 (Table 3.0-19). In comparison to the No Action Alternative, the increase in training activities presented in Alternative 1 increases the risk of sea turtles being exposed to munitions; however, the expected impact on any exposed sea turtle remains the same. Sub-lethal effects due to ingestion of munitions used in training activities may cause short-term or long-term disturbance to an individual turtle. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the use of munitions of ingestible size during training activities under Alternative 1 would have not affect on leatherback sea turtles. The use of munitions of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

Testing Activities

The number of small- and medium-caliber projectiles (the only ingestible sizes) and explosives are detailed in Tables 3.0-18 and 3.0-19. Any bottom-feeding turtle may occur in the area where these are used, but green, olive ridley, and loggerhead turtles are most likely.

Sublethal effects due to ingestion of munitions used in testing activities may cause short-term or long-term disturbance to an individual turtle because: (1) if a sea turtle were to incidentally ingest and swallow a projectile or solid metal high-explosive fragment, it could potentially disrupt its feeding behavior or digestive processes; and (2) if the item is particularly large in proportion to the turtle ingesting it, the item could become permanently encapsulated by the stomach lining, with a rare chance that this could impede the turtle’s ability to feed or take in nutrients. Potential impacts of exposure to munitions may result in changes to an individual’s behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, munitions used in testing activities are generally not expected to cause disturbance to sea turtles because: (1) sea turtles are not expected to encounter most small- and medium-caliber projectiles or high-explosive fragments on the seafloor because of the depth at which these would be expended; and (2) in some cases a turtle would likely pass the projectile through their digestive tract and expel the item without impacting the individual. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the use of munitions of ingestible size during testing activities under Alternative 1 would have no effect on leatherback sea turtles. The use of munitions of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

3.5.3.5.1.3 Alternative 2

Training Activities

Under Alternative 2, the amount of small- and medium-caliber projectiles approximately doubles that of the No Action Alternative, from 86,500 to 173,890 projectiles (Table 3.0-18). The number of activities that use high-explosive ordnance and munitions increases from 1,340 under the No Action Alternative to 10,284 under Alternative 2 (Table 3.0-19). In comparison to the No Action Alternative, the increase in training activities presented in Alternative 1 increases the risk of sea turtles being exposed to munitions; however, the expected impact on any exposed sea turtle remains the same. Sub-lethal effects due to ingestion of munitions used in training activities may cause short-term or long-term disturbance to an individual turtle. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the use of munitions of ingestible size during training activities under Alternative 2 would have no effect on leatherback sea turtles. The use of munitions of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

Testing Activities

Under Alternative 2, the number of small- and medium-caliber projectiles (the only ingestible sizes) and explosives are detailed in Tables 3.0-18 and 3.0-19. Any bottom-feeding turtle may occur in areas where projectiles and explosives are used, but green, olive ridley, and loggerhead turtles are most likely.

Sublethal effects due to ingestion of munitions used in testing activities may cause short-term or long-term disturbance to an individual turtle because: (1) if a sea turtle were to incidentally ingest and swallow a projectile or solid metal high-explosive fragment, it could potentially disrupt its feeding behavior or digestive processes; and (2) if the item is particularly large in proportion to the turtle ingesting it, the item could become permanently encapsulated by the stomach lining, with a rare chance that this could impede the turtle's ability to feed or take in nutrients. Potential impacts of exposure to munitions may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, munitions used in testing activities are generally not expected to cause disturbance to sea turtles because: (1) sea turtles are not expected to encounter most small- and medium-caliber projectiles or high-explosive fragments on the seafloor because of the depth at which these would be expended; and (2) in some cases, a turtle would likely pass the projectile through their digestive tract and expel the item without impacting the individual. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the use of munitions of ingestible size during testing activities under Alternative 2 would have no effect on leatherback sea turtles. The use of munitions of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

3.5.3.5.2 Impacts from Military Expended Materials Other than Munitions

Fragments from targets, chaff, flare casings, and decelerators/parachutes are ingestion stressors introduced during training and testing activities and are being analyzed for sea turtles. A discussion of the types of these devices is presented in Sections 3.0.5.2.5.3 (Military Expended Materials Other than Munitions).

Because leatherbacks are more likely to feed at or near the surface, they are more likely to encounter materials at the surface than are other species of turtles that primarily feed along the seafloor. Furthermore, leatherbacks typically feed in the open ocean, while other species are more likely to feed in nearshore areas. Though they are bottom-feeding species that generally feed nearshore, green, hawksbill, olive ridley and loggerhead sea turtles may occur in the open ocean during migrations. Given the very low probability of nearshore, bottom-feeding species encountering and ingesting materials at the surface, this analysis focuses on leatherback sea turtles and those materials expended in the open ocean.

3.5.3.5.2.1 No Action Alternative

<u>Training Activities</u>

Under the No Action Alternative, some training activities use decelerators/parachutes of ingestible size. Under the No Action Alternative, approximately 8,032 decelerators/parachutes would be expended in locations greater than 3 nm from shore throughout the MITT Study Area (see Table 3.0-25). Activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600.4 ft.). Because the decelerators/parachutes sink, they are not expected to drift into another portion of the Study Area. Because of the low number of sonobuoys expended in the open ocean and the rapid sink rate of the decelerator/parachute, the likelihood of a leatherback encountering and ingesting a decelerator/parachute is extremely low. Because of the water depth over which these decelerators/parachutes are deployed, other sea turtle species are not likely to encounter a decelerator/parachute after it sinks through the water column.

Under the No Action Alternative, approximately 5,836 chaff cartridges would be expended by ships and aircraft during training activities (see Table 3.0-26). Although these fibers are too small for sea turtles to confuse with prey and forage, there is some potential for chaff to be incidentally ingested along with other prey items. If ingested, chaff is not expected to impact sea turtles, due to the low concentration that would be ingested and the small size of the fibers.

While no similar studies to those discussed in Section 3.0.5.2.5.3 (Military Expended Materials Other Than Munitions) on the effects of chaff have been conducted on sea turtles, they are also not likely to be impacted by incidental ingestion of chaff fibers. For instance, some sea turtles ingest spicules (small spines within the structure of a sponge) in the course of eating the sponges, without harm to their digestive system. Since chaff fibers are of similar composition and size as these spicules (Spargo 1999), ingestion of chaff should be inconsequential for sea turtles.

Sublethal effects due to ingestion of munitions used in training activities may cause short-term or long-term disturbance to an individual turtle because: (1) if a sea turtle were to incidentally ingest and swallow a projectile or solid metal high-explosive fragment, it could potentially disrupt its feeding behavior or digestive processes; and (2) if the item is particularly large in proportion to the turtle ingesting it, the projectile could become permanently encapsulated by the stomach lining, with a rare chance that this could impede the turtle's ability to feed or take in nutrients. Potential impacts of exposure to munitions may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, munitions used in training activities are generally not expected to cause disturbance to sea turtles because: (1) sea turtles are not expected to encounter most small- and medium-caliber projectiles or high-explosive fragments on the seafloor because of the depth at which these would be expended; and (2) in some cases a turtle would likely pass the projectile through their digestive tract and expel the item without impacting the individual. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the ingestion of military expended materials other than munitions during training activities under the No Action Alternative would have no effect on leatherback sea turtles. The use of materials of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

Testing Activities

Under the No Action Alternative, no activities that would create ingestion stressors are conducted in the Study Area.

3.5.3.5.2.2 Alternative 1

Training Activities

Under Alternative 1, approximately 10,845 decelerators/parachutes would be expended during training activities in areas greater than 3 nm from shore throughout the MITT Study Area (see Table 3.0-25). The expended chaff would increase to approximately 25,840 canisters per year in areas greater than 3 nm from shore within the MITT Study Area compared with the No Action Alternative of 5,830 (see Table 3.0-26). The expended flares would increase to approximately 25,600 canisters per year in areas greater than 3 nm from shore within the MITT Study Area (see Table 3.0-27).

All sea turtle species would have the potential to be exposed to decelerators/parachutes, chaff, or flares in the Study Area, but given the very low probability of nearshore, bottom-feeding species encountering and ingesting materials at the surface, leatherback sea turtles are more likely to be exposed.

In comparison to the No Action Alternative, the increase in training activities presented in Alternative 1 increases the risk of sea turtles being exposed to decelerators/parachutes, chaff, and flares; however, the expected impact on any exposed sea turtle remains the same. For the same reasons stated for the No Action Alternative, sub-lethal effects due to ingestion of military expended materials other than munitions used in training activities may cause short-term or long-term disturbance to an individual turtle.

Pursuant to the ESA, the ingestion of military expended materials other than munitions during training activities under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under Alternative 1, some testing activities use decelerators/parachutes of ingestible size. Approximately 1,727 decelerators/parachutes would be expended in locations greater than 3 nm from shore throughout the MITT Study Area (see Table 3.0-25). Activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600.4 ft.). Because the decelerators/parachutes sink, they are not expected to drift into another portion of the Study Area. Because of the low number of sonobuoys expended in the open ocean and the rapid sink rate of the decelerator/parachute, the likelihood of a leatherback encountering and ingesting a decelerator/parachute is extremely low. Because of the water depth over which these decelerators/parachutes are deployed, other sea turtle species are not likely to encounter a decelerator/parachute after it sinks through the water column.

Pursuant to the ESA, the ingestion of military expended materials other than munitions during testing activities under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.5.2.3 Alternative 2

Training Activities

The number and location of training activities under Alternative 2 are identical to training activities under Alternative 1. Therefore, impacts and comparisons to the No Action Alternative will be identical, and conclusions made for Alternative 1 are the same for Alternative 2.

Pursuant to the ESA, the ingestion of military expended materials other than munitions during training activities under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under Alternative 2, some testing activities use decelerators/parachutes of ingestible size. Approximately 1,912 decelerators/parachutes would be expended in locations greater than 3 nm from shore throughout the MITT Study Area (see Table 3.0-25). Activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600.4 ft.). Because the decelerators/parachutes sink, they are not expected to drift into another portion of the Study Area. Because of the low number of sonobuoys expended in the open ocean and the rapid sink rate of the decelerator/parachute, the likelihood of a leatherback encountering and ingesting a decelerator/parachute is extremely low. Because of the water depth over which these decelerators/parachutes are deployed, other sea turtle species are not likely to encounter a decelerator/parachute after it sinks through the water column.

Pursuant to the ESA, the ingestion of military expended materials other than munitions during testing activities under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.6 Secondary Stressors

This section analyzes potential impacts on sea turtles exposed to stressors indirectly through effects on habitat and prey availability from impacts associated with sediments and water quality. For the purposes of this analysis, secondary effects on sea turtles via sediment or water (not by trophic transfer, e.g., bioaccumulation) are considered here. It is important to note that the terms “indirect” and “secondary” do not imply reduced severity of environmental consequences, but instead describe *how* the impact may occur to an organism.

Stressors from Navy training and testing activities could pose secondary or indirect impacts on turtles via changes in habitat, sediment, or water quality. These include explosives and byproducts, metals, chemicals, and impacts on habitat. Activities associated with these stressors are detailed in Tables 2.8-1 to 2.8-4 and analyses of their potential impacts are discussed in Section 3.1 (Sediments and Water Quality) and Section 3.3 (Marine Habitats).

3.5.3.6.1 Explosives

In addition to the potential to affect turtle and turtle habitat, underwater explosions could affect other species in the food web, including prey species that sea turtles feed upon. The impacts of underwater explosions would differ, depending on the type of prey species in the area of the blast.

In addition to the physical effects of an underwater blast, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to detonations that might include swimming to the surface or scattering away from the source. This startle and flight response is the most common secondary defense among animals (Mather 2004). The abundance of prey species near the detonation point could be diminished for a short period before being repopulated by animals from adjacent waters. Many sea turtle prey items, such as jellyfish and sponges, have limited mobility and ability to react to pressure waves. Any of these scenarios would be temporary, only occurring during activities involving explosives, and no lasting effect on prey availability or the pelagic food web would be expected. The Navy avoids conducting activity in ESA-listed coral habitats, which would minimize secondary effects to sea turtle species that rely on these habitats. Furthermore, most explosions occur in depths exceeding that which normally support seagrass beds, again protecting these habitats.

Strike warfare activities such as BOMBEX (Land) and MISSILEX involve the use of live munitions by aircrews that practice on ground targets on FDM. These warfare training activities occur on FDM and are limited to the designated impact zones along the central corridor of the island. Training activities may contribute to ongoing soil disturbance and erosion from natural causes on FDM and potential erosion of beach habitat. However, sea turtle nests are unlikely to be encountered on the beaches of FDM, which are unsuitable for nesting due to tidal inundation.

3.5.3.6.2 Explosion Byproducts and Unexploded Ordnance

Any explosive material not completely consumed during a detonation from ordnance disposal and mine clearance are collected after training is complete; therefore, potential impacts are assumed to be inconsequential and not detectable for these training and testing activities. Sea turtles may be exposed by contact with the explosive material, contact with contaminants in the sediment or water, and ingestion of contaminated sediments.

High-order explosions consume most of the explosive material, creating typical combustion products. In the case of Royal Demolition Explosive, 98 percent of the products are common seawater constituents and the remainder are rapidly diluted below threshold effect level (Table 3.1-9). Explosive byproducts from high-order detonations present no secondary stressors to turtles through sediment or water. However, low-order detonations and unexploded ordnance present elevated likelihood of impacts on sea turtles.

Secondary effects of explosives and unexploded ordnance on turtles via sediment are possible near the ordnance. Degradation of explosives proceeds via several pathways discussed in Section 3.1.3.1 (Explosives and Explosive Byproducts). Degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Rosen and Lotufo 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6 to 12 in. (15.2 to 30.5 cm) away from degrading ordnance, concentrations of these compounds were not statistically distinguishable from background beyond 3 to 6 ft. (0.9 to 1.8 m) from the degrading ordnance (see Section 3.1.3.1.5.1, Explosives and Explosive Byproducts). Various lifestages of turtles could be impacted by the indirect effects of degrading explosives within a small radius of the explosive 1 to 6 ft. (0.3 to 1.8 m).

3.5.3.6.3 Metals

Metals are introduced into seawater and sediments by training and testing activities involving vessel hulks, targets, ordnance, munitions, and other military expended materials (see Section 3.1.3.2, Metals), the majority of which are deposited throughout the MITT Study Area (greater than 3 nm from shore). Some metals bioaccumulate, and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals (Section 3.3, Marine Habitats, and Chapter 4, Cumulative Impacts). Indirect impacts of metals on sea turtles via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. Sea turtles may be exposed by contact with the metal, contact with contaminants in the sediment or water, or ingestion of contaminated sediments, though this exposure is anticipated to be minimal with deposition of metals in water depths greater than the diving ability of a sea turtle. Concentrations of metals in seawater are orders of magnitude lower than concentrations in marine sediments. It is extremely unlikely that sea turtles would be indirectly impacted by toxic metals via water.

3.5.3.6.4 Chemicals

Several Navy training and testing activities introduce potentially harmful chemicals into the marine environment; principally, flares and propellants for rockets, missiles, and torpedoes. Polychlorinated biphenyls (PCBs) are discussed in Section 3.1.3.3 (Chemicals Other Than Explosives). PCBs have a variety of effects on aquatic organisms. The chemicals persist in the tissues of animals at the bottom of the food chain. Thereafter, consumers of those species tend to accumulate PCBs at levels that may be many times higher than in water. In the past, PCBs have been raised as an issue because they have been found in certain solid materials on vessels used as targets during vessel-sinking exercises (e.g., insulation, wires, felts, and rubber gaskets). Currently, vessels used for sinking exercises are selected from a list of U.S. Navy-approved vessels that have been cleaned in accordance with EPA guidelines. Properly functioning flares missiles, rockets, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment. Sea turtles may be exposed by contact with contaminated water or ingestion of contaminated sediments.

Missile and rocket fuel poses no risk of secondary impact on sea turtles via sediment. In contrast, the principal toxic components of torpedo fuel, propylene glycol dinitrate and nitrodiphenylamine, adsorbs to sediments, has relatively low toxicity, and is readily degraded by biological processes. It is conceivable that various lifestages of sea turtles could be indirectly impacted by propellants via sediment in the immediate vicinity of the object (e.g., within a few inches), but these potential effects would diminish rapidly as the propellant degrades.

3.5.3.6.5 No Action Alternative, Alternative 1, and Alternative 2 – Training

Pursuant to the ESA, secondary stressors resulting from training activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but are not likely to adversely affect green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles sea turtles.

3.5.3.6.6 No Action Alternative, Alternative 1, and Alternative 2 – Testing

Pursuant to the ESA, secondary stressors resulting from testing activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but are not likely to adversely affect green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles sea turtles.

3.5.4 Summary of Impacts on Sea Turtles

3.5.4.1 Combined Impacts of All Stressors

As described in Section 3.0.5.4 (Resource-Specific Impacts Analysis for Multiple Stressors), this section evaluates the potential for combined impacts of all the stressors from the Proposed Action. The analysis and conclusions for the potential impacts from each of the individual stressors are discussed in the analyses of each stressor in the sections above and summarized in Endangered Species Act Determinations.

There are generally two ways that a sea turtle could be exposed to multiple stressors. The first would be if the animal were exposed to multiple sources of stress from a single activity (e.g., a mine warfare activity may involve explosives and vessels that could introduce potential acoustic and physical strike stressors). The potential for a combination of these impacts from a single activity would depend on the range of effects to each of the stressors and the response or lack of response to that stressor. Most of the activities as described in the Proposed Action involve multiple stressors; therefore, it is likely that if a sea turtle were within the potential impact range of those activities, they may be impacted by multiple stressors simultaneously. This would be more likely to occur during large-scale exercises or activities that span a period of days or weeks (such as a sinking exercise or composite training unit exercise).

Secondly, an individual sea turtle could be exposed to a combination of stressors from multiple activities over the course of its life. This is most likely to occur in areas where training and testing activities are more concentrated (e.g., near naval ports, testing ranges, and routine activity locations) and in areas that individual sea turtles frequently visit because it is within the animal's home range, migratory route, breeding area, or foraging area. Except for in the few concentrated areas mentioned above, combinations are unlikely to occur because training and testing activities are generally separated in space and time in such a way that it would be very unlikely that any individual sea turtles would be exposed to stressors from multiple activities. However, animals with a small home range intersecting an area of concentrated Navy activity have elevated exposure risks relative to animals that simply transit the area through a migratory route. Also, the majority of the proposed training and testing activities occur over a small spatial scale relative to the entire Study Area, have few participants, and are of a short duration (the order of a few hours or less).

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 strike and disturbance stressors via a decreased ability to detect and avoid threats. Sea turtles that experience behavioral and physiological consequences of ingestion stressors could be more susceptible to physical strike stressors via malnourishment and disorientation. These interactions are speculative, and without data on the combination of multiple Navy stressors, the synergistic impacts from the combination of Navy stressors on sea turtles are difficult to predict.

Although potential impacts on certain sea turtle species from the Proposed Action could include injury or mortality, impacts are not expected to decrease the overall fitness or result in long-term population-level impacts of any given population. In cases where potential impacts rise to the level that warrants mitigation, mitigation measures designed to reduce the potential impacts are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), which include safe speeds during operations, lookouts, and mitigation zones with shutdown procedures if animals enter during activities. The potential impacts anticipated from the Proposed Action are summarized in Endangered Species Act Determinations with respect to the ESA.

3.5.5 Endangered Species Act Determinations

Administration of ESA obligations associated with sea turtles are shared between NMFS and USFWS, depending on life stage and specific location of the sea turtle. NMFS has jurisdiction over sea turtles in the marine environment, and USFWS has jurisdiction over sea turtles on land. The Navy is consulting with NMFS on its determination of effect on the potential impacts of the Proposed Action. Because no nesting for any species of sea turtle is known to occur in the Study Area, consultation with USFWS is not required for sea turtles. Table 3.5-12 summarizes the Navy's determination of effect on ESA listed sea turtles for the Proposed Action.

Table 3.5-12: Summary of Effects and Impact Determinations for Sea Turtles

Stressor		Green Turtle	Hawksbill Turtle	Loggerhead Turtle	Olive Ridley Turtle	Leatherback Turtle
Acoustic Stressors						
Sonar and Other Active Acoustic Sources	Training Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, likely to adversely affect
	Testing Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, likely to adversely affect
Explosives	Training Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Swimmer Defense Airguns	Training Activities	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Testing Activities	No effect	No effect	No effect	No effect	No effect
Weapons Firing, Launch, and Impact Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Vessel and Aircraft Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Energy Stressors						
Electromagnetic Devices	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

Table 3.5-12: Summary of Effects and Impact Determinations for Sea Turtles (continued)

Stressor		Green Turtle	Hawksbill Turtle	Loggerhead Turtle	Olive Ridley Turtle	Leatherback Turtle
Physical Disturbance and Strike						
Vessels	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
In-Water Devices	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Military Expended Materials	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Seafloor Devices	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Entanglement Stressors						
Fiber Optic Cables and Guidance Wires	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Decelerators/ Parachutes	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

Table 3.5-12: Summary of Effects and Impact Determinations for Sea Turtles (continued)

Stressor		Green Turtle	Hawksbill Turtle	Loggerhead Turtle	Olive Ridley Turtle	Leatherback Turtle
Ingestion						
Munitions	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	No effect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	No effect
Military Expended Materials other than Munitions	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

REFERENCES

Abreu-Grobois, A & Plotkin, P. (2008). Lepidochelys olivacea. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on 4 March 2013.

Aguirre, A. A. & Lutz, P. L. (2004). Marine Turtles as Sentinels of Ecosystem Health: Is Fibropapillomatosis an Indicator? *EcoHealth, 1*, 275-283. 10.1007/s10393-004-0097-3

Alfaro-Shigueto, J., Mangel, J.C., Bernedo, F., Dutton, P.H., Seminoff J.A. & Godley, B.J. (2011). Small-scale fisheries of Peru: a major sink for marine turtles in the Pacific. *Journal of Applied Ecology,* 48, 1432-1440.

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

Balazs, G. H. (1980). *Synopsis of Biological Data on the Green Turtle in the Hawaiian Islands*. (NOAA-TM-NMFS-SWFC-7, pp. 141) U.S. Department of Commerce, Naitonal Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Balazs, G. H. & Chaloupka, M. (2004). Thirty-year recovery trend in the once depleted Hawaiian green sea turtle stock. *Biological Conservation, 117*, 491-498.

Balazs, G. H., Craig, P., Winton, B. R. & Miya, R. K. (1994). Satellite telemetry of green turtles nesting at French Frigate Shoals, Hawaii, and Rose Atoll, American Samoa. In K. A. Bjorndal, A. B. Bolten, D. A. Johnson and P. J. Eliazar (Eds.), *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation*. (NOAA Technical Memorandum NMFS-SEFSC-351, pp. 184-187) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

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

Bartol, S. M. & Ketten, D. R. (2006). Turtle and tuna hearing. In Y. Swimmer and R. W. Brill (Eds.), *Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries*. (NOAA Technical Memorandum NMFS-PIFSC-7, pp. 98-103) Pacific Islands Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration and U.S. Department of Commerce.

Bartol, S. M. & Musick, J. A. (2003). Sensory Biology of Sea Turtles P. L. Lutz, J. A. Musick and J. Wyneken (Eds.), *The Biology of Sea Turtles* (Vol. 2, pp. 16).

Bastinal, P. (2002). Sabah Turtle Islands Park, Malaysia. Presented at the Western Pacific Sea Turtle Cooperative Research & Management Workshop, Honolulu, Hawaii.

Beavers, S. C. andCassano, E. R. (1996). Movements and Dive Behavior of a Male Sea Turtle (Lepidochelys olivacea) in the Eastern Tropical Pacific. *Journal of Herpetology*, Vol. 30, No. 1., pp. 97-104.

Benoit-Bird, K.J., Au, W.W.L., Brainard, R.E., Lammers, M.O. (2001). Diel horizontal migration of the Hawaiian mesopelagic boundary community observed acoustically. *Marine Ecology Progress Series*, 217, 1-14.

Benson, S. R., Eguchi, T., Foley, D. G., Forney, K. A., Bailey, H., Hitipeuw, C., Samber, B.P., Tapilatu, R.F., Rei, V., Ramohia, P., Pita, J. and Dutton, P. H. (2011). Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. *Ecosphere, 2*(7).

Benson, S. R., Forney, K. A., Harvey, J. T., Carretta, J. V. & Dutton, P. H. (2007). Abundance, distribution, and habitat of leatherback turtles (Dermochelys coriacea) off California, 1990-2003. *Fishery Bulletin, 105*(3), 337-347.

Bjorndal K.A., Bolten, A.B., Martins, H.R. (2000). Somatic growth model of juvenile loggerhead sea turtles Caretta caretta: duration of pelagic stage. *Marine Ecology Progress Series*, 202, 265-272.

Bjorndal, K., Bolten, A. & Lagueux, C. (1994). Ingestion of Marine Debris by Juvenile Sea Turtles in Coastal Florida Habitats. [Electronic Version]. *Marine Pollution Bulletin, 28*(3), 154-158. 0025-326X/94

Bjorndal, K. A. (1995). The consequences of herbivory for the life history pattern of the green turtle, *Chelonia mydas*. In K. A. Bjorndal (Ed.), *Biology and Conservation of Sea Turtles* (Revised ed., pp. 111-116). Washington, DC: Smithsonian Institution Press.

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

Bjorndal, K. A. (2003). Roles of loggerhead sea turtles in marine ecosystems. In A. B. Bolten and B. E. Witherington (Eds.), *Loggerhead Sea Turtles* (pp. 235-254). Washington, DC: Smithsonian Institution Press.

Bjorndal, K. A. & Bolten, A. B. (1988). Growth rates of immature green turtles, *Chelonia mydas*, on feeding grounds in the southern Bahamas. *Copeia, 1988*(3), 555-564.

Blumenthal, J. M., Austin, T. J., Bothwell, J. B., Broderick, A. C., Ebanks-Petrie, G., Olynik, J. R., Orr, A.C., Solomon, J.L., Witt, M.J., and Godley, B. J. (2009). Diving behavior and movements of juvenile hawksbill turtles *Eretmochelys imbricata* on a Caribbean coral reef. *Coral Reefs, 28*(1), 55-65. doi: 10.1007/s00338-008-0416-1

Blumenthal, J.M., Solomon, J.L., Bell, C.D., Austin, T.J., Ebanks-Petrie, G., Coyne, M.S., Broderick, A.C., Godley, B.J. (2006). Satellite tracking highlights the need for international cooperation in marine turtle management. *Endangered Species Management*, 7, 1-11.

Bowen, B. W. & Karl, S. A. (1997). Population genetics, phylogeography, and molecular evolution. In P. L. Lutz and J. A. Musick (Eds.), *The Biology of Sea Turtles* (pp. 29-50). Boca Raton, FL: CRC Press.

Bresette, M., Singewald, D. & De Maye, E. (2006). Recruitment of post-pelagic green turtles (*Chelonia mydas*) to nearshore reefs on Florida's east coast. In M. Frick, A. Panagopoulou, A. F. Rees and K. Williams (Eds.), *Book of Abstracts: Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation* (Abstract, pp. 288). Athens, Greece: International Sea Turtle Society.

Brill, R. W., Balazs, G. H., Holland, K. N., Chang, R. K. C., Sullivan, S. & George, J. C. (1995). Daily movements, habitat use, and submergence intervals of normal and tumor-bearing juvenile green turtles (*Chelonia mydas* L.) within a foraging area in the Hawaiian islands. *Journal of Experimental Marine Biology and Ecology, 185*(2), 203-218.

Burke, V. J., Morreale, S. J., Logan, P. & Standora, E. A. (1991). Diet of Green Turtles (*Chelonia mydas*) in the Waters of Long Island, N.Y. *NOAA Technical Memorandum NMFS-SEFSC-302*. Presented at the Eleventh Annual Workshop on Sea Turtle Biology and Conservation, Jekyll Island, Georgia.

Caillouet, C. W., Koi, D. B., Fontaine, C. T., Williams, T. D., Browning, W. J., and Harris, R. M. (1986). Growth and Survival of Kemp's Ridley Sea Turtle, Lepidochelys kempi, in captivity. NOAA Technical Memorandum, NMFS-SEFC-186 pp. 1-34.

Carr, A. (1986). Rips, FADS, and little loggerheads. *BioScience, 36*(2), 92-100.

Carr, A. (1987). New perspectives on the pelagic stage of sea turtle development. *Conservation Biology, 1*(2), 103-121.

Carr, A., Carr, M. & Meylan, A. B. (1978). The ecology and migrations of sea turtles, 7. The west carribean green turtle colony. *Bulletin of the American Museum of Natural History, 162*(1), 1-46.

Carr, A. & Meylan, A. B. (1980). Evidence of passive migration of green turtle hatchlings in *Sargassum*. *Copeia, 1980*(2), 366-368.

Casale P, Broderick AC, Freggi D, Mencacci R, Fuller WJ, Godley BJ, Luschi P. (2012). Long-term residence of juvenile loggerhead turtles to foraging grounds: a potential conservation hotspot in the Mediterranean. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 22(2). 144-154.

Chaloupka, M., Dutton, P. & Nakano, H. (2004). Status of sea turtle stocks in the Pacific. In *Papers Presented at the Expert Consultation on Interactions between Sea Turtles and Fisheries Within an Ecosystem Context*. (FAO Fisheries Report No. 738, Supplement, pp. 135-164). Rome, Italy: United Nations Environment Programme, Food and Agriculture Organization of the United Nations.

Chaloupka, M., K.A. Bjorndal, G.H. Balazs, A.B. Boltern, L.M. Ehrhart, C.J. limpus, H. Suganuma, S. Troeng, M. Yamaguchi. (2008a). Encouraging outlook for recovery of a once severely exploited marine megaherbivore. Global Ecology and Biogeography, 17, 297-304.

Chaloupka, M., Work, T., Balazs, G., Murakawa, S. & Morris, R. (2008b). Cause-specific temporal and spatial trends in green sea turtle strandings in the Hawaiian Archipelago (1982-2003). *Marine Biology, 154*, 887-898.

Chaloupka, M. Balazs, G. H. Work, T. M. (2009). Rise and Fall over 26 years of a Marine Epizootic in Hawaiian Green Sea Turtles. *Journal of Wildlife Diseases*, 45 (4), 1138-1142.

Chaloupka, M. Y. & Musick, J. A. (1997). Age, growth, and population dynamics. In P. L. Lutz and J. A. Musick (Eds.), *The Biology of Sea Turtles* (pp. 233-276). Boca Raton, FL: CRC Press.

Chan, S. K. F., Cheng, I. J., Zhou, T., Wang, H. J., Gu, H. X., and Song, X. J. (2007). A comprehensive overview of the population and conservation status of sea turtles in China. Chelonian Conservation and Biology, 6(2), 185-198.

Christensen-Dalsgaard, J., Brandt, C., Willis, K. L., Christensen, C. B., Ketten, D., Edds-Walton, P., Fay, R. R. (2012). Specialization for underwater hearing by the tympanic middle ear of the turtle, Trachemys scripta elegans. *Proceedings of the Royal Society B: Biological Sciences*. doi:10.1098/rspb.2012.0290Crognale et al. 2008.

Clark, S. L. & Ward, J. W. (1943). The Effects of Rapid Compression Waves on Animals Submerged In Water. *Surgery, Gynecology & Obstetrics, 77*, 403-412.

Cliffton, K., Cornejo, D. O. & Felger, R. S. (1995). Sea turtles of the Pacific coast of Mexico. In K. A. Bjorndal (Ed.), *Biology and Conservation of Sea Turtles* (Revised ed., pp. 199-209). Washington, DC: Smithsonian Institution Press.

Conant, T. A., Dutton, P. H., Eguchi, T., Epperly, S. P., Fahy, C. C., Godfrey, M. H., MAcPherson, S.L., Possardt, E.E., Schroeder, B.A., Seminoff, J.A., Snover, C.M., and Witherington, B. E. (2009). *Loggerhead Sea Turtle (*Caretta caretta*) 2009 Status Review under the U.S. Endangered Species Act*. (pp. 222) Loggerhead Biological Review Team and National Marine Fisheries Service.

Cook, S. L. & Forrest, T. G. (2005). Sounds produced by nesting leatherback sea turtles (*Dermochelys coriacea*). *Herpetological Review, 36*(4), 387-390.

Costanzo, F.A. (2010). Underwater explosion phenomena and shock physics. Proceedings of the IMAC-XXVIII. February 1-4 2010, Jacksonville, FL, USA.

Craig, J. C., Jr. & Hearn, C. W. (1998). Appendix D. Physical impacts of explosions on marine mammals and turtles *Final Environmental Impact Statement on Shock Testing of the Seawolf Submarine* (pp. D1-D41). North Charleston, South Carolina: Department of the Navy.

Craig, J. C., Jr. & Rye, K. W. (2008). Appendix D: Criteria and thresholds for injury *Shock Trial of the Mesa Verde (LPD 19)*. Arlington, VA: Chief of Naval Operations, U.S. Navy.

Craig Jr., J. C. (2001). Appendix D, Physical Impacts of Explosions on Marine Mammals and Turtles *Final Environmental Impact Statement, Shock Trial of the WINSTON CHURCHILL (DDG 81)* (Final, pp. 43). U.S. Department of the Navy, Naval Sea Systems Command (NAVSEA).

Crognale, M.A., Eckert, S.A., Levenson, D.H., & Harms, C.A. (2008). Leatherback sea turtle *Dermochelys coriacea* visual capacities and potential reduction of bycatch by pelagic longline fisheries. Endangered Species Research, 5, 249-256.

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

Dobbs, K. A., Miller, J. D., Limpus, C. J. & Landry, A. M., Jr. (1999). Hawksbill turtle, *Eretmochelys imbricate*, nesting at Milman Island, northern Great Barrier Reef, Australia. *Chelonian Conservation and Biology, 3*(2), 344-361.

Dodd, C. K., Jr. (1988). *Synopsis of the Biological Data on the Loggerhead Sea Turtle* Caretta caretta *(Linnaeus 1758)*. (Biological Report 88(14), pp. 110). Washington, D.C.: U.S. Fish and Wildlife Service.

Dodge, K. L., Galuardi, B., Miller, T. J., and Lutcavage, M. E. (2014). Leatherback turtle movements, dive behavior, and habitat characteristics in ecoregions of the Northwest Atlantic Ocean. PloS one, 9(3), e91726.

Dow Piniak W.E., S.A. Eckert, C.A. Harms & E.M. Stringer. (2012a). Underwater hearing sensitivity of the leatherback sea turtle (*Dermochelys coriacea*): Assessing the potential effect of anthropogenic noise. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Headquarters, Herndon, VA. OCS Study BOEM 2012-01156. 35pp.

Dow Piniak, W. E., Harms, C.A., Stringer, E.M., Eckert, S.A. (2012b). "Hearing sensitivity of hatchling leatherback sea turtles (Dermochelys coriacea)." 32nd Annual Symposium on Sea Turtle Biology and Conservation.

Dow Piniak, W.E., Eckert, S.A., Mann, D.A., & Horrocks, J.A. (2011). Amphibious hearing in hatchling hawksbill sea turtles (Eretmochelys imbricata). IN: Jones, T.T., and Wallace, B.P. compilers. (2012) Updated November 2012. Proceedings of the Thirty-first Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NOAA NMFS-SEFSC-631: 322p.

Doyle, T. K., Houghton, J. D., O'Súilleabháin, P. F., Hobson, V. J., Marnell, F., Davenport, J., and Hays, G. C. (2008). Leatherback turtles satellite-tagged in European waters. Endangered Species Research, 4, 23-31.

Dutton, P. (2006). Building our knowledge of the leatherback stock structure. *SWoT Report-State of the World's Sea Turtles, I*, 10-11. Retrieved from http://seaturtlestatus.org/report/swot-volume-1

Dutton, P. H., Hitipeuw, C., Zein, M., Benson, S. R., Petro, G., Pita, J., Rei, V., Ambio, L., and Bakarbessy, J. (2007, 2007/05/01). Status and Genetic Structure of Nesting Populations of Leatherback Turtles (Dermochelys coriacea) in the Western Pacific. *Chelonian Conservation and Biology, 6*(1), 47-53.

Eckert, S. A., Nellis, D. W., Eckert, K. L., and Kooyman, G. L. (1986). Diving Patterns of Two Leatherback Sea Turtles (*Dermochelys Coriacea*) During Internesting Intervals at Sandy Point, St. Croix, U.S. Virgin Islands. *Herpetologica*, 42(3), 381-388.

Eckert, G. L. (1987). Environmental unpredictability and leatherback sea turtle (*Dermochelys coriacea*) nest loss. *Herpetologica, 43*(3), 315-323.

Eckert, K.L., Wallace, B.P., Frazier, J.G., Eckert, S.A., Pritchard, P.C.H. (2012). Synopsis of the Biological Data on the Leatherback Sea Turtle (Dermochelys coriacea). U.S. Fish & Wildlife Service Biological Technical Publication, BTP-R4015-2012.

Eckert, K. L. (1993). *The Biology and Population Status of Marine Turtles in the North Pacific Ocean*. (NOAA-TM-NMFS-SWFSC-186, pp. 166) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Eckert, K. L. (1995). Anthropogenic threats to sea turtles. In K. A. Bjorndal (Ed.), *Biology and Conservation of Sea Turtles* (Revised ed., pp. 611-612). Washington, DC: Smithsonian Institution Press.

Eckert, K. L., Bjorndal, K. A., Abreu-Grobois, F. A. & Donnelly, M. (Eds.). (1999). *Research and Management Techniques for the Conservation of Sea Turtles*. (IUCN/SSC Marine Turtle Specialist Group Publication No. 4, pp. 24).

Eckert, K. L. & Eckert, S. A. (1988). Pre-reproductive movements of leatherback sea turtles (*Dermochelys coriacea*) nesting in the Caribbean. *Copeia, 2*, 400-406.

Eckert, K. L., Eckert, S. A., Adams, T. W. & Tucker, A. D. (1989). Inter-nesting migrations by leatherback sea turtles (*Dermochelys coriacea*) in the West Indies. *Herpetologica, 45*(2), 190-194.

Eckert, S. A. (2002). Distribution of juvenile leatherback sea turtle *Dermochelys coriacea* sightings. *Marine Ecology Progress Series, 230*, 289-293.

Eckert, S. A., Eckert, K. L., Ponganis, P. & Kooyman, G. L. (1989). Diving and foraging behavior of leatherback sea turtles (*Dermochelys coriacea*). *Canadian Journal of Zoology, 67*, 2834-2840.

Eckert, S. A. & Sarti-Martinez, L. (1997). Distant fisheries implicated in the loss of the world's largest leatherback nesting population. *Marine Turtle Newsletter, 78*, 2-7. Retrieved from http://www.seaturtle.org/mtn/archives/mtn78/mtn78p2.shtml

Eguchi, T., Gerrodette, T., Pitman, R. L., Seminoff, J. A. & Dutton, P. H. (2007). At-sea density and abundance estimates of the olive ridley turtle *Lepidochelys olivacea* in the eastern tropical Pacific. *Endangered Species Research, 3*(2), 191-203.

Eisenberg, J. F. & Frazier, J. (1983). A leatherback turtle (*Dermochelys coriacea*) feeding in the wild. *Journal of Herpetology, 17*(1), 81-82.

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

Encalada, S.E., Bjorndal, K.A., Bolten A.B., Zurita, J.C. Schroeder, B., Possardt, E., Sears C. J., Bowen, B.W. (1998). Population structure of loggerhead turtle (*Caretta caretta*) nesting colonies in the Atlantic and Mediterranean as inferred from mitochondrial DNA control region sequences. *Marine Biology*, 130, 567-575.

Finneran, J. J., Schlundt, C. E., Dear, R., Carder, D. A. & Ridgway, S. H. (2002). Temporary Shift in Masked Hearing Thresholds in Odontocetes After Exposure to Single Underwater Impulses from a Seismic Watergun. *Journal of the Acoustical Society of America, 111*(6), 2929-2940.

Fonseca, L.G., Murillo, G.A., Guadamuz, L., Spinola, R.M., and Valverde, R.A. (2009). Downward but Stable Trend in the Abundance of Arribada Olive Ridley Sea Turtles (Lepidochelys olivacea) at Nancite Beach, Costa Rica (1971–2007). Chelonian Conservation and Biology, 2009, 8(1), 19–27.

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

Frick, M. G., Williams, K. L., Bolten, A. B., Bjorndal, K. A., Martins, H. R. (2009). Foraging ecology of oceanic-stage loggerhead turtles *Caretta caretta*. *Endangered Speices Research*, Vol. 9: 91-97.

Fritts, T. (1981). Pelagic feeding habits of turtles in the eastern pacific. *Marine Turtle Newsletter, 17*(1).

Fuentes, M.M.P.B., Limpus, C.J. & Hamann, M. (2011). Vulnerability of sea turtle nesting grounds to climate change. Global Change Biology, 17, 140–153.

Fuxjager, M., Eastwood, B.S., & Lohmann, K. (2011). Orientation of hatchling loggerhead sea turtles to regional magnetic fields along a transoceanic migratory pathway. *The Journal of Experimental Biology, 214*, 2504-2508.

Gaos, A. R. (2011). *Spatial Ecology of Hawksbill Turtles (Eretmochelys Imbricata) in the Eastern Pacific Ocean.* San Diego State University, San Diego, California.

Gerstein, E., Gerstein, L., Greenewald, J. & Forsythe, S. (2009). Parametric Projectors Protecting Marine Mammals from Vessel Collisions. [Electronic Version]. Presented at the Acoustical Society of America 157th Meeting Lay Language Papers, Portland OR. Retrieved from http://www.acoustics.org/press/157th/gerstein.html

Godley, B. J., Blumenthal, J. M., Broderick, A. C., Coyne, M. S., Godfrey, M. H., Hawkes, L. A., & Witt, M. J. (2008). Satellite tracking of sea turtles: Where have we been and where do we go next? Endnagered Species Research, 4, 3-22.

Godley, B. J., Broderick, A. C., Glen, F. & Hays, G. C. (2003). Post-nesting movements and submergence patterns of loggerhead marine turtles in the Mediterranean assessed by satellite tracking. *Journal of Experimental Marine Biology and Ecology, 287*, 119-134.

Godley, B. J., Richardson, S., Broderick, A. C., Coyne, M. S., Glen, F. & Hays, G. C. (2002). Long-term satellite telemetry of the movements and habitat utilisation by green turtles in the Mediterranean. *Ecography, 25*(3), 352-362.

Godley, B. J., Thompson, D. R., Waldron, S. & Furness, R. W. (1998). The trophic status of marine turtles as determined by stable isotope analysis. *Marine Ecology Progress Series, 166*, 277-284.

Goertner, J. F. (1982). Prediction of underwater explosion safe ranges for sea mammals. (NSWC TR 82-188, pp. 38 pp.). Silver Spring, MD: Naval Surface Weapons Center, Dahlgren Division, White Oak Detachment.

Goertner, J. F., Wiley, M. L., Young, G. A. & McDonald, W. W. (1994). Effects of underwater explosions on fish without swimbladders. (NSWC TR 88-114). Silver Spring, MD: Naval Surface Warfare Center.

Grant, G. S. & Ferrell, D. (1993). Leatherback turtle, *Dermochelys coriacea* (Reptilia: *Dermochelidae*): Notes on near-shore feeding behavior and association with cobia. *Brimleyana, 19*, 77-81.

Greaves, F. C., Draeger, R. H., Brines, O. A., Shaver, J. S. & Corey, E. L. (1943). An Experimental Study of Concussion. *United States Naval Medical Bulletin, 41*(1), 339-352.

Gregory, L. F. & Schmid, J. R. (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

Hailman, J.P., and Elowson, A.M. (1992). Ethogram of the Nesting Female Loggerhead (*Caretta caretta*). *Herpetologica*, 48(1), 1-30.

Hatase, H., Omuta, K. & Tsukamoto, K. (2007). Bottom or midwater: alternative foraging behaviours in adult female loggerhead sea turtles. *Journal of Zoology, 273*(1), 46-55.

Hatase, H., Matsuzawa, Y., Sakamoto, W., Baba, N. & Miyawaki, I. (2002). Pelagic habitat use of an adult Japanese male loggerhead turtle *Caretta caretta* examined by the Argos satellite system. *Fisheries Science, 68*, 945-947.

Hatase, H., Sato, K., Yamaguchi, M., Takahashi, K. & Tsukamoto, K. (2006). Individual variation in feeding habitat use by adult female green sea turtles (Chelonia mydas): are they obligately neritic herbivores? *Oecologia, 149*(1), 52-64.

Hawkes, L. A., Broderick, A. C., Godfrey, M. H. and Godley, B. J. (2009). Climate change and marine turtles. Endangered Species Research 7, 137-154.

Hawkes, L.A., Broderick, A.C., Coyne, M.S., Godfrey, M.H., & Godley, B.J. (2007). Only some like it hot — quantifying the environmental niche of the loggerhead sea turtle. Diversity and Distributions, 13, 447–457.

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

Hays, G. C., Adams, C. R., Broderick, A. C., Godley, B. J., Lucas, D. J., Metcalfe, J. D. & Prior, A. A. (2000). The diving behavior of green turtles at Ascension Island. *Animal Behavior, 59*, 577-586.

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

Hays, G. C., Houghton, J. D. R. & Myers, A. E. (2004b). Pan-Atlantic leatherback turtle movements. *Nature, 429*, 522.

Hays, G. C., Metcalfe, J. D. & Walne, A. W. (2004c). The implications of lung-regulated buoyancy control for dive depth and duration. *Ecology, 85*(4), 1137-1145.

Hazel, J. (2009). Evaluation of fast-acquisition GPS in stationary tests and fine-scale tracking of green turtles. Journal of Experimental Marine Biology and Ecology, 374, 58–68.

Hazel, J., Lawler, I. R., Marsh, H. & Robson, S. (2007). Vessel speed increase collision risk for the green turtle *Chelonia mydas*. *Endangered Species Research, 3*, 105-113.

Heithaus, M. R., McLash, J. J., Frid, A., Dill, L. M. & Marshall, G. (2002). Novel insights into green sea turtle behaviour using animal-borne video cameras. *Journal of the Marine Biological Association of the United Kingdom, 82*(6), 1049-1050.

Hill, M.S. (1998). Spongivory on Caribbean reefs releases corals from competition with sponges. Oecologia, 117, 143-150.

Hirth, H., Kasu, J. & Mala, T. (1993). Observations on a Leatherback Turtle *Dermochelys coriacea* Nesting Population near Piguwa, Papua New Guinea. *Biological Conservation, 65*, 77-82.

Hirth, H. F. (1997). *Synopsis of the Biological Data on the Green Turtle* Chelonia mydas *(Linnaeus 1758)*. (Biological Report 97(1)). Washington, DC: U.S. Fish and Wildlife Service.

Hirth, H. F. & Ogren, L. H. (1987). *Some Aspects of the Ecology of the Leatherback Turtle* Dermochelys coriacea *at Laguna Jalova, Costa Rica*. *NOAA Technical Report NMFS 56, pp 14*.

Hitipeuw, C., Dutton, P. H., Benson, S., Thebu, J. & Bakarbessy, J. (2007). Population status and internesting movement of leatherback turtles, *Dermochelys coriacea*, nesting on the northwest coast of Papua, Indonesia. *Chelonian Conservation and Biology, 6*(1), 28-36.

Hochscheid, S., Bentivegna, F. & Hays, G. C. (2005). First records of dive durations for a hibernating sea turtle. *Biology Letters, 1*, 82-86.

Hochscheid, S., Bentivegna, F., Bradai, M.N., Hays, G.C. (2007). Overwintering behaviour in sea turtles: dormancy is optional. Marine Ecology Progress Series, 340, 287-298.

Houghton, J.D.R., Doyle, T.K., Davenport, J., Wilson, R.P., and Hays, G.C. (2008). The role of infrequent and extraordinary deep dives in leatherback turtles (Dermochelys coriacea). The Journal of Experimental Biology 211, 2566-2575.

Howell, E. A., Dutton, P. H., Polovina, J. J., Bailey, H., Parker, D. M. & Balazs, G. H. (2010). Oceanographic influences on the dive behavior of juvenile loggerhead turtles (*Caretta caretta*) in the North Pacific Ocean. *Marine Biology, 157*(5), 1011-1026.

Hughes, G. R., Luschi, P., Mencacci, R. & Papi, F. (1998). The 7000-km oceanic journey of a leatherback turtle tracked by satellite. *Journal of Experimental Marine Biology and Ecology, 229*, 209-217.

I-Jiunn, C. (2009). Changes in diving behaviour during the internesting period by green turtles. *Journal of Experimental Marine Biology and Ecology, 381*(1), 18-24. doi: 10.1016/j.jembe.2009.08.021

Ishihara, T., & Kamezaki, K. (2011). Size at Maturity and Tail Elongation of Loggerhead Turtles (Caretta caretta) in the North Pacific. Chelonian Conservation and Biology, 10(2):281-287.

James, M. C. & Herman, T. B. (2001). Feeding of *Dermochelys coriacea* on medusae in the northwest Atlantic. *Chelonian Conservation and Biology, 4*(1), 202-205.

James, M. C. & Mrosovsky, N. (2004). Body temperatures of leatherback turtles (*Dermochelys coriacea*) in temperate waters off Nova Scotia, Canada. *Canadian Journal of Zoology, 82*, 1302-1306.

James, M. C., Myers, R. A. & Ottensmeyer, C. A. (2005). Behaviour of leatherback sea turtles, *Dermochelys coriacea*, during the migratory cycle. *Proceedings of the Royal Society B: Biological Sciences, 272*, 1547-1555.

James, M. C., Sherrill-Mix, S. A., Martin, K. & Myers, R. A. (2006). Canadian waters provide critical foraging habitat for leatherback sea turtles. *Biological Conservation, 133*(3), 347-357.

Jensen, M.P., Abreu-Grobois, F.A., Frydenberg, J., & Loeschcke, V. (2006). Microsatellites provide insight into contrasting mating patterns in arribada vs. non-arribada olive ridley sea turtle rookeries. Molecular Ecology, 15, 2567–2575.

Jones, T.T. (2009). Energetics of the leatherback turtle (Dermochelys coriacea). Ph.D. Thesis, The University of British Columbia, Vancouver.

Jones, T.J., and K.S. Van Houtan. (2014). Sea Turtle Tagging in the Mariana Islands Range Complex (MIRC). January; Annual Progress Report. Prepared for the U.S. Navy by the Marine Turtle Assessment Group, Protected Species Division, Pacific Islands Fisheries Science Center, National Marine Fisheries Service, Honolulu, Hawaii.

Jonsen, I. D., Myers, R. A. & James, M. C. (2007). Identifying leatherback turtle foraging behaviour from satellite telemetry using a switching state-space model. *Marine Ecology Progress Series, 337*, 255-264.

Kalb, H. & Owens, D. (1994). Differences between solitary and arribada nesting olive ridley females during the internesting period. In K. A. Bjorndal, A. B. Bolten, D. A. Johnson and P. J. Eliazar (Eds.), *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation*. (NOAA Technical Memorandum NMFS-SEFSC-351, pp. 68) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Kamezaki, N., Matsuzawa, Y., Abe, O., Asakawa, H., Fujii, T., Goto, K. Hagino, S., Hayami, M., Ishii, M., Iwamoto, T., Kamata, t., Kato, H., Kodama, J., Kondo, Y., Miyawaki, I., Mizobuchi, K., Nakamura, Y., Nakashima, Y., Naruse, H., Omuta, K., Samejima, M., Suganuma, H., Takeshita, H., Tanaka, T., Toji, T., Uematsu, M., Yamamoto, A., Yamato, T., and Wakabayashi, I. (2003). Loggerhead Turtles Nesting in Japan. In Bolten, A.B. & Witherington, B.E. (Eds.), Loggerhead Sea Turtles (pp 210-217). Washington: Smithsonian Books.

Keinath, J. A. & Musick, J. A. (1993). Movements and diving behavior of a leatherback turtle, *Dermochelys coriacea*. *Copeia, 1993*(4), 1010-1017.

Ketten, D. R. (1995). Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions R. A. Kastelein, J. A. Thomas and P. E. Nachtigall (Eds.), *Sensory Systems of Aquatic Mammals* (pp. 391-407). Woerden, The Netherlands: De Spil Publishers.

Ketten, D. R. (1998). Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and Its Implications for Underwater Acoustic Impacts. Dolphin-Safe Research Program, Southwest Fisheries Science Center, La Jolla, CA.

Ketten, D. R. (2008). Underwater ears and the physiology of impacts: comparative liability for hearing loss in sea turtles, birds, and mammals. Bioacoustics, 17, 312-315.

Ketten, D. R., Lien, J. & Todd, S. (1993). Blast injury in humpback whale ears: Evidence and implications (A). *Journal of the Acoustical Society of America, 94*(3), 1849-1850.

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

Kobayashi, D. R., Polovina, J. J., Parker, D. M., Kamezaki, N., Cheng, I. J., Uchida, I., Durron, P.H., and Balazs, G. H. (2008). Pelagic habitat characterization of loggerhead sea turtles, Caretta caretta, in the North Pacific Ocean (1997–2006): Insights from satellite tag tracking and remotely sensed data. *Journal of Experimental Marine Biology and Ecology, 356*(1-2), 96-114.

Kolinski, S. P., Hoeke, R. K., Holzwarth, S. R., Ilo, L. I., Cox, E. F., O'Conner, R. C. & Vroom, P. S. (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).

Kolinski, S. P., Parker, D. M., Ilo, L. I. & Ruak, J. K. (2001). An Assessment of the Sea Turtles and Their Marine and Terrestrial Habitats at Saipan, Commonwealth of the Northern Mariana Islands. *Micronesica, 34*(1), 55-72.

Lavender, A.l., Bartol, S.M., Bartol, I.K. (2011). A two-method approach for investigating the underwater hearing capabilities of loggerhead sea turtles (Caretta caretta). Abstract. Society for Integrative and Comparitive Biology, 2012 Annual Meeting.

Lazell, J. D., Jr. (1980). New England waters: Critical habitat for marine turtles. *Copeia, 1980*(2), 290-295.

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

Lenhardt, M. L. (1994). Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). In K. A. Bjorndal, A. B. Bolten, D. A. Johnson and P. J. Eliazar (Eds.), *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation*. (NOAA Technical Memorandum NMFS-SEFSC-351, pp. 238-241). Hilton Head, South Carolina: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, and Southeast Fisheries Science Center.

Lenhardt, M. L. (2002). Sea turtle auditory behavior. [Abstract]. *Journal of the Acoustical Society of America, 112*(5, Part 2), 2314.

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

Lenhardt, M. L., Klinger, R. C. & Musick, J. A. (1985). Marine Turtle Middle-Ear Anatomy. *The Journal of Auditory Research, 25*, 66-72.

Leon, Y.M. & Bjorndal, K.A. (2002). Selective feeding in the hawksbill turtle, an important predator in coral reef ecosystems. Marine Ecology Progress Series, 245, 249-258.

Levenson, D. H., Eckert, S. A., Crognale, M. A., Deegan, J. I. & Jocobs, G. H. (2004). Photopic spectral sensitivity of green and loggerhead sea turtles. *Copeia*(4), 908–914.

Lewison, R.L., Freeman, S.A., and Crowder, L.B. (2004). Quantifying the effects of fisheries on threatened species: the impact of pelagic longlines on loggerhead and leatherback sea turtles. Ecology Letters 7, 221–231

Limpus, C. J. (1992). The hawksbill turtle, *Eretmochelys imbricata*, in Queensland: population structure within a southern Great Barrier Reef ground. *Wildlife Research, 19*, 489-506.

Limpus, C. (2008). A biological review of Australian marine turtle species. 1. Loggerhead turtle, Caretta caretta (Linneaus). The Queensland Environmental Protection Agency.

Limpus, C. J. (2009). A Biological Review of Australian Marine Turtles Hawksbill Turtle, *Eretmochelys imbricata* (Linnaeus). (pp. 54) Queensland Government Environmental Protection Agency.

Lohmann, K. J. (1991). Magnetic Orientation by Hatchling Loggerhead Sea Turtles (Caretta caretta). *Journal of experimental Biology* 155, 37-49.

Lohmann, K. J. & Lohmann, C. M. F. (1992). Orientation to oceanic waves by green turtle hatchlings. *Journal of Experimental Biology, 171*, 1-13.

Lohmann, K. J. & Lohmann, C. M. F. (1996a). Detection of magnetic field intensity by sea turtles. *Nature, 380*, 59-61. doi:10.1038/380059a0

Lohmann, K. J. & Lohmann, C. M. F. (1996b). Orientation and open-sea navigation in sea turtles. *Journal of Experimental Biology, 199*(1), 73-81.

Lohmann, K. J. & Lohmann, C. M. F. (2006). Sea turtles, lobsters, and oceanic magnetic maps. *Marine and Freshwater Behaviour and Physiology, 39*(1), 49-64.

Lohmann, K. J., Witherington, B. E., Lohmann, C. M. F. & Salmon, M. (1997). Orientation, navigation, and natal beach homing in sea turtles. In P. L. Lutz and J. A. Musick (Eds.), *The Biology of Sea Turtles* (pp. 107-136). Boca Raton, FL: CRC Press.

López-Mendilaharsu, M., Rocha, C. F., Domingo, A., Wallace, B. P., and Miller, P. (2009). Prolonged deep dives by the leatherback turtle Dermochelys coriacea: pushing their aerobic dive limits. Marine Biodiversity Records, 2, e35.

Lund, F. P. (1985). Hawksbill Turtle (Eretmochelys imbricata) Nesting on the East Coast of Florida. *Journal of Herpetology, 19*(1), 166-168.

Lutcavage, M., Plotkin, P., Witherington, B. & Lutz, P. (1997). Human impacts on sea turtle survival. In P. Lutz and J. A. Musick (Eds.), *The Biology of Sea Turtles* (Vol. 1, pp. 387–409). Boca Raton, FL: CRC Press.

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

Maison, K. A., Kelly, I. K. & Frutchey, K. P. (2010). *Green Turtle Nesting Sites and Sea Turtle Legislation throughout Oceania*. (NOAA Technical Memorandum NMFS-F/SPO- 110, pp. 56) U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Marine Fisheries Service.

Makowski, C., Seminoff, J. A. & Salmon, M. (2006). Home range and habitat use of juvenile Atlantic green turtles (*Chelonia mydas* L.) on shallow reef habitats in Palm Beach, Florida, USA. *Marine Biology, 148*, 1167-1179.

Mansfield K.L., Saba, V.S., Keinath, J.A., & Musick, J.A. (2009). Satellite tracking reveals a dichotomy in migration strategies among juvenile loggerhead turtles in the Northwest Atlantic. Marine Biology, 156, 2555-2570.

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

Márquez M., R. (1990). *FAO Species Catalogue: SeaTurtles of the World. An Annotated and Illustrated Catalogue of Sea Turtle Species known to date.* (Vol. 11, FAO Fisheries Synopsis. No. 125, pp. 81). Rome, Italy: United Nations Environment Programme, Food and Agriculture Organization of the United Nations.

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M.-N., Penrose, J. D., McCabe, K. A. (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. (R99-15, pp. 198). Western Australia: Centre for Marine Science and Technology.

McCauley, S. & Bjorndal, K. (1999). Conservation Implications of Dietary Dilution from Debris Ingestion: Sublethal Effects in Post-Hatchling Loggerhead Sea Turtles. *Conservation biology, 13*(4), 925-929.

McClellan C.M., J. Braun-McNeill, Avens, L., WALLACE, B.P., & Read, A.J. (2010). Stable isotopes confirm a foraging dichotomy in juvenile loggerhead sea turtles. Journal of Experimental Marine Biology and Ecology, 387, 44-51.

McClellan, C. M. & Read, A. J. (2007). Complexity and variation in loggerhead sea turtle life history. *Biology Letters, 3*, 592-594.

McMahon C.R., Bradshaw, C.J.A., & Hays, G.C. (2007). Satellite tracking reveals unusual diving characteristics for a marine reptile, the olive ridley turtle Lepidochelys olivacea. Marine Ecology Progress Series, 329, 239-252.

McVey, J. P., and Wibbels, T. (1984). The Growth and Movements of Cap-Tive-Reared Kemp's Ridley Sea Turtles, Lepidochelys Kempi, Following their Release in the Gulf of Mexico. *NOAA Technical Memorandum*, NMFS-SEFC-145.

Meylan, A. (1995). Sea turtle migration - evidence from tag returns. In K. A. Bjorndal (Ed.), *Biology and Conservation of Sea Turtles* (Revised ed., pp. 91-100). Washington, DC: Smithsonian Institution Press.

Meylan, A. B. (1988). Spongivory in hawksbill turtles: A diet of glass. *Science, 239*, 393-395.

Meylan, A. B. & Donnelly, M. (1999). Status justification for listing the hawksbill turtle (*Eretmochelys imbricata*) as critically endangered on the 1996 *IUCN Red List of Threatened Animals*. *Chelonian Conservation and Biology, 3*(2), 200-224.

Miller, J.D., Limpus, C.J., and Godfrey, M.H. (2003). Nest Site Selection, Oviposition, Eggs, Development, Hatching, and Emergence of Loggerhead Turtles. In Bolten, A.B. & Witherington, B.E. (Eds.), Loggerhead Sea Turtles (pp 125-143). Washington: Smithsonian Books.

Moein Bartol, S. E., Musick, J. A., Keinath, J. A., Barnard, D. E., Lenhardt, M. L. & George, R. (1995). Evaluation of Seismic Sources for Repelling Sea Turtles from Hopper Dredges 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.

Mortimer, J. A. (1995). Feeding ecology of sea turtles. In K. A. Bjorndal (Ed.), *Biology and Conservation of Sea Turtles* (Revised ed., pp. 103-109). Washington, DC: Smithsonian Institution Press.

Mortimer, J. A. & Donnelly, M. (2008). *Hawksbill Turtle (*Eretmochelys imbricate*): Marine Turtle Specialist Group 2008 IUCN Red List status assessment*.

Mortimer, J. A. & Portier, K. M. (1989). Reproductive homing and internesting behavior of the green turtle (*Chelonia mydas*) at Ascension Island, South Atlantic Ocean. *Copeia, 1989*, 962-977.

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

Musick, J. A. & Limpus, C. J. (1997). Habitat utilization and migration of juvenile sea turtles. In P. L. Lutz and J. A. Musick (Eds.), *The Biology of Sea Turtles* (pp. 137-163). Boca Raton, FL: CRC Press.

Myers, A. E. & Hays, G. C. (2006). Do leatherback turtles *Dermochelys coriacea* forage during the breeding season? A combination of data-logging devices provide new insights. *Marine Ecology Progress Series, 322*, 259-267.

National Marine Fisheries Service. (2010). Endangered and threatened species; proposed rule to revise the critical habitat designation for the Endangered leatherback sea turtle; extension of public comment period. [Proposed Rule]. *Federal Register, 75*(33), 7434-7435.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (1991). *Recovery Plan for U.S. Populations of Atlantic Green Turtle* Chelonia mydas. (pp. 52). Washington, DC: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (1992). *Recovery Plan for Leatherback Turtles* Dermochelys coriacea *in the U.S. Carribean, Atlantic and Gulf of Mexico*. (pp. 65). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (1998a). *Recovery Plan for U.S. Pacific Populations of the East Pacific Green Turtle (*Chelonia mydas*)*. (pp. 61). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (1998b). *Recovery Plan for U.S. Pacific Populations of the Green Turtle (*Chelonia mydas*)*. (pp. 84). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (1998c). *Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*)*. (pp. 83). Silver Spring, MD: National Marine Fisheires Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (1998d). *Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (*Dermochelys coriacea*)*. (pp. 65). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (1998e). *Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*)*. (pp. 59). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (1998f). *Recovery Plan for U.S. Pacific Populations of the Olive Ridley Turtle (*Lepidochelys olivacea*)*. (pp. 52). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (2007a). *Green Sea Turtle (*Chelonia mydas*) 5-year Review: Summary and Evaluation*. (pp. 102). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (2007b). *Hawksbill Sea Turtle (*Eretmochelys imbricata*) 5-year Review: Summary and Evaluation*. (pp. 90). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (2007c). *Leatherback Sea Turtle (*Dermochelys coriacea*) 5-year Review: Summary and Evaluation*. (pp. 79). Silver Spring, MD: National Marine Fisheries.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (2007d). *Loggerhead Sea Turtle (*Caretta caretta*) 5-year Review: Summary and Evaluation*. (pp. 65). Silver Spring, MD: National Marine Fisheries.

National Marine Fisheries Service and U.S. Fish and Wildlife. (2009). *Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (Caretta caretta)* [Second Revision]. (pp. 325). Silver Spring, MD: National Marine Fisheries Service.

National Research Council. (2010). *Assessment of Sea-Turtle Status and Trends: Integrating Demography and Abundance* (pp. 190). Washington, DC: The National Academies Press. Retrieved from http://www.nap.edu/catalog/12889.html.

Nmosovsky, N. (2001). World's Largest Aggregation of Sea Turtles to be Jettisoned. *Marine Turtle Newsletter* 63: S2-3.

Normandeau, Exponent, T., T. & Gill, A. (2011). Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. Camarillo, CA: U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region. Available from http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/4/5115.pdf

Okuyama, J., Shimizu, T., Osamu, A., Yoseda, K., Arai, N. (2010). Wild versus head-started hawksbill turtles *Eretmochelys imbricata*: post-release behavior and feeding adaptations. *Endangered Species Research*, Preprint.

Parker, D. M. & Balazs, G. H. (2005). Diet of the oceanic green turtle, *Chelonia mydas*, in the north Pacific. In H. Kalb, A. S. Rohde, K. Gayheart and K. Shanker (Eds.), *Proceedings of the Twenty-fifth Annual Symposioum on Sea Turtle Biology and Conservation* [Abstract]. (NOAA Technical Memorandum NMFS-SEFSC-582, pp. 94) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Parker, L. G. (1995). Encounter with a juvenile hawksbill turtle offshore Sapelo Island, Georgia. *Marine Turtle Newsletter, 71*, 19-22. Retrieved from http://www.seaturtle.org/mtn/archives/mtn71/mtn71p19.shtml

Peckham, S.H., Diaz, D.M., Walli, A., Ruiz, G., Crowder, L.B. (2007). Small-Scale Fisheries Bycatch Jeopardizes Endangered Pacific Loggerhead Turtles. PLoS ONE 2(10): e1041.

Pelletier, D., Roos, D. & Ciccione, S. (2003). Oceanic survival and movements of wild and captive-reared immature green turtles (*Chelonia mydas*) in the Indian Ocean. *Aquatic Living Resources, 16*, 35-41.

Pepper, C. B., Nascarella, M. A. & Kendall, R. J. (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.

Pitman, R. L. (1990). Pelagic distribution and biology of sea turtles in the eastern tropical Pacific. In T. H. Richardson, J. I. Richardson and M. Donnelly (Eds.), *Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation*. (NOAA Technical Memorandum NMFS-SEFC-278, pp. 143-150) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Plotkin, P.T. (2010). Nomadic behaviour of the highly migratory olive ridley sea turtle Lepidochelys olivacea in the eastern tropical Pacific Ocean. Endangered Species Research, 13, 33-40.

Plotkin, P. T., Byles, R. A. & Owens, D. W. (1994). Post-breeding movements of male olive ridley sea turtles *Lepidochelys olivacea* from a nearshore breeding area. In K. A. Bjorndal, A. B. Bolton, D. A. Johnson and P. J. Eliazar (Eds.), *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation* [Abstract]. (NOAA Technical Memorandum NMFC-SEFSC-351) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Poloczanska, E.S., Limpus, C.J. &Hays, G.C. (2009). Vulnerability of Marine Turtles to Climate Change. In D. W. Sims, editor: Advances in Marine Biology, Vol. 56, Burlington: Academic Press, 2009, pp. 151-211.

Polovina, J. J., Balazs, G. H., Howell, E. A., Parker, D. M., Seki, M. P. & Dutton, P. H. (2004). Forage and migration habitat of loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific Ocean. *Fisheries Oceanography, 13*(1), 36-51.

Polovina, J. J., Howell, E., & Balazs, G. H. (2003). Dive-depth distribution of loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific: Might deep longline sets catch fewer turtles? *Fishery Bulletin, 101*(1), 189-193.

Polovina, J.J., Howell, E., Kobayashi, D.R., and Seki, M.P. (2001). The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. *Progress in Oceanography*, 49, 469-483.

Polovina, J.J., Kobayashi, D.R., Parker, D.M., Seki, M.P., and Balazs, G.H. (2000). Turtles on the edge: movement of loggerhead turtles (*Caretta caretta*) along oceanic fronts, spanning longline fishing grounds in the central North Pacific, 1997-1998. *Fisheries Oceanography*, 9, 71-82.

Popper, A.N., A.D.Hawkins, R.R. Fay, D. Mann, S. Bartol, Th. Carlson, S. Coombs, W.T. Ellison, R. Gentry, M.B. Halvorsen, S. Lokkeborg, P. Rogers, B.L. Southall, D.G. Zeddies, 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.

Pritchard, P. C. H. (1982). Nesting of the Leatherback Turtle, Dermochelys coriacea in Pacific Mexico, with a New Estimate of the World Population Status. *Copeia*, Vol. 1982, No. 4, pp. 741-747.

Pritchard, P. C. H. (1997). Evolution, phylogeny, and current status. In P. L. Lutz and J. A. Musick (Eds.), *The Biology of Sea Turtles* (pp. 1-28). Boca Raton, FL: CRC Press.

Pritchard, P. C. H. & Plotkin, P. T. (1995). Olive ridley sea turtle, *Lepidochelys olivacea*. In P. T. Plotkin (Ed.), *National Marine Fisheries Service and U.S. Fish and Wildlife Service Status Reviews of Sea Turtles Listed under the Endangered Species Act of 1973.* (pp. 123-139). Silver Spring, MD: National Marine Fisheries Service.

Pultz, S., O'Daniel, D. O., Krueger, S. & McSharry, H. (1999). Marine Turtle Survey on Tinian, Mariana Islands. *Micronesica, 31*(2), 85-94.

Putnam, N. F., Endres, C. S., Lohmann, C. M. F. & Lohmann, K. J. (2011). Longitude perception and biocoordinate magnetic maps in sea turtles. *Current Biology, 21*, 463-466.

Rees, A. F., Frick, M., Panagopoulou, A. & Williams, K. (2008). Proceedings of the twenty-seventh annual symposium on sea turtle biology and conservation National Oceanic and Atmospheric Administration Technical Memorandum. (pp. 262).

Reich, K. J., Bjorndal, K. A., Bolten, A. B. & Witherington, B. (2007). Do some loggerheads nesting in Florida have an oceanic foraging strategy? An assessment based on stable isotopes. In R. B. Mast, B. J. Hutchinson and A. H. Hutchinson (Eds.), *Proceedings of the Twenty-fourth Annual Symposium on Sea Turtle Biology and Conservation* [Abstract]. (NOAA Technical Memorandum NMFS-SEFSC-567, pp. 32) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Renaud, M. L. & Carpenter, J. A. (1994). Movements and submergence patterns of loggerhead turtles (*Caretta caretta*) in the Gulf of Mexico determined through satellite telemetry. *Bulletin of Marine Science, 55*(1), 1-15.

Rice, M. R. & Balazs, G. H. (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.

Richardson and McGillivary (1991). Proceedings of the twenty-fourth annual symposium on sea turtle biology and conservation. NOAA Technical Memorandum NMFS-SEFSC-567.

Richardson, J. I., Bell, R. & Richardson, T. H. (1999). Population ecology and demographic implications drawn from an 11-year study of nesting hawksbill turtles, *Eretmochelys imbricata*, at Jumby Bay, Long Island, Antigua, West Indies. *Chelonian Conservation and Biology, 3*(2), 244-250.

Richmond, D. R., Yelverton, J. T. & Fletcher, E. R. (1973). Far-field underwater-blast injuries produced by small charges. (DNA 3081T, pp. 108). Washington, DC: Lovelace Foundation for Medical Education and Research, Defense Nuclear Agency.

Ridgway, S. H., Scronce, B. L. & Kanwisher, J. (1969). Respiration and deep diving in the bottlenose porpoise. *Science, 166*, 1651-1654.

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

Rosen, G. & Lotufo, G. R. (2010). Fate and effects of composition B in multispecies marine exposures. *Environmental Toxicology and Chemistry, 9999*(12), 1-8. doi: 10.1002/etc.153

Rupeni, E., S. Mangubhai, K. Tabunakawai, and P. Blumel. (2002). Establishing replicable community-based turtle conservation reserves in Fiji. Pages 119-124 in Kinan, I. (editor). Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop. Western Pacific Regional Fishery Management Council.

Sagun, V.G., Romoso Jr., N.B., and Mejino, B.H. (2005). New records on the distribution of loggerhead turtles (*Caretta caretta*) in the Phillipines. *Marine Turtle Newsletter*, 107, 12.

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

Sale, A., Luschi, P., Mencacci, R., Lambardi, P., Hughes, G. R., Hays, G. C., Benvenuti, S., and Papi, F. (2006). Long-term monitoring of leatherback turtle diving behaviour during oceanic movements. *Journal of Experimental Marine Biology and Ecology, 328*, 197-210.

Salmon, M., Jones, T. T. & Horch, K. W. (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.

Sarti-Martinez, A. L. (2000). *Dermochelys coriacea*, *IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2*.

Sarti-Martinez, L., Eckert, S. A., Garcia T., N. & Barragan, A. R. (1996). Decline of the world's largest nesting assemblage of leatherback turtles. *Marine Turtle Newsletter, 74*, 2-5. Retrieved from http://www.seaturtle.org/mtn/archives/mtn74/mtn74p2.shtml

Sasso, C. R. & Witzell, W. N. (2006). Diving behaviour of an immature Kemp's ridley turtle (*Lepidochelys kempii*) from Gullivan Bay, Ten Thousand Islands, south-west Florida. *Journal of the Marine Biological Association of the United Kingdom, 86*, 919-925.

Schecklman, S., Houser, D., Cross, M., Hernandez, D. & Siderius, M. (2011). Comparison of methods used for computing the impact of sound on the marine environment. *Marine Environmental Research, 71*, 342-350.

Schofield, G., Hobson, V. J., Lilley, M. K. S., Katselidis, K. A., Bishop, C. M., Brown, P. & Hays, G. C. (2010). Inter-annual variability in the home range of breeding turtles: Implications for current and future conservation management. *Biological Conservation, 143*(3), 722-730.

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

Schuyler, Q., Hardesty, B.D., Wilcox, C., Townsend, K. (2012). To Eat or Not to Eat? Debris Selectivity by Marine Turtles. PLoS ONE 7(7): e40884.

Seminoff, J.A., Zarate, P., Coyne, M., Foley, D.G., Parker, D., Lyon, B.N., Dutton, P.H. (2008). Post-nesting migrations of Galapagos green turtles Chelonia mydas in relation to oceanographic conditions: integrating satellite telemetry with remotely sensed ocean data. Endnagered Species Research, 4, 57-72.

Seminoff, J. A. & Marine Turtle Specialist Group Green Turtle Task Force. (2004). *Marine Turtle Specialist Group Review: 2004 Global Status Assessment, Green turtle (*Chelonia mydas*)*. (pp. 71) The World Conservation Union (IUCN) Species Survival Commission, Red List Programme.

Seminoff, J. A., Resendiz, A. & Nichols, W. J. (2002). Home range of green turtles *Chelonia mydas* at a coastal foraging area in the Gulf of California, Mexico. *Marine Ecology Progress Series, 242*, 253-265.

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

Snover, M. L., Hohn, A. A., Crowder, L. B., and Macko, S. A. (2010). Combining stable isotopes and skeletal growth marks to detect habitat shifts in juvenile loggerhead sea turtles Caretta caretta. Endangered Species Research, 13(1), 25-31.

Southall B.L., Bowles A.E., Ellison W.T., Finneran J.J., Gentry R.L., Greene Jr. C.R., Kastak D., Ketten D.R., Miller J.H., Nachtigall P.E., Richardson W.J., Thomas J.A., Tyack P.L. (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals 33:411-521.

Southwood, A., Fritsches, K., Brill, R. & Swimmer, Y. (2008). Sound, chemical, and light detection in sea turtles and pelagic fishes: sensory-based approaches to bycatch reduction in longline fisheries. Endangered Species Research, 5, 225-238.

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

Spargo, B.J. 1999. Environmental Effects of RF Chaff: a Select Panel Report to the Undersecretary of Defense for Environmental Security. NRL/PU/6100—99-389, Washington, D.C.

Spotila, J. R., Dunham, A. E., Leslie, A. J., Steyermark, A. C., Plotkin, P. T. & Paladino, F. V. (1996). Worldwide population decline of *Dermochelys coriacea*: Are leatherback turtles going extinct? *Chelonian Conservation and Biology, 2*(2), 209-222.

Spotila, J. R., Reina, R. D., Steyermark, A. C., Plotkin, P. T. & Paladino, F. V. (2000). Pacific leatherback turtles face extinction. *Nature, 405*, 529-530.

Stancyk, S. E. (1982). Non-human predators of sea turtles and their control. In K. A. Bjorndal (Ed.), *Biology and Conservation of Sea Turtles* (pp. 139-152). Washington, DC: Smithsonian Institution Press.

Stanley, S., Wetmore, K. & Kennett, J. (1988). Macroevolutionary Differences Between the Two Major Clades of Neogene Planktonic Foraminifera. [Electronic Version]. *Paleobiology, 14*(3 [Summer 1988]), 235-249.

State of the World's Sea Turtles. (2012). State of the World's Turtles Nesting Sites. Online Map Viewer. Available at http://seamap.env.duke.edu/swot. Accessed 7 March 2013.

Storch, S., Wilson, R. P., Hillis-Starr, Z. M. & Adelung, D. (2005). Cold-blooded divers: temperature-dependent dive performance in the wild hawksbill turtle *Eretmochelys imbricata*. *Marine Ecology Progress Series, 293*, 263-271.

Stuhmiller, J. H., Pillips, Y. Y., Richmond, D. R. (1991). The Physics and Mechanisms of Primary Blast Injury. *Conventional Warfare: Ballistic, Blast, and Burn Injuries*. Office of the Surgeon General. pp. 241-270.

Suarez, A., Dutton, P. H. & Bakarbessy, J. (2000). Leatherback (*Dermochelys coriacea*) nesting on the north Vogelkop coast of Irian Jaya, Indonesia. In H. Kalb and T. Wibbels (Eds.), *Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation* [Abstract]. (NOAA Technical Memorandum NMFS-SEFSC-443, pp. 260) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Tapilatu, R.F. & Tiwari, M. (2007). Leatherback Turtle, *Dermochelys coriacea*, Hatching Success at Jamursba-Medi and Wermon Beaches in Papua, Indonesia. Chelonian Conservation and Biology, 6(1), 154-158.

Tiwari, M., Balazs, G. H., and Hargrove, S. (2010). Estimating carrying capacity at the green turtle nesting beach of East Island, French Frigate Shoals. Marine Ecology Progress Series, 419, 289-294.

Tomas, J., Guitart, R., Mateo, R. & Raga, J. A. (2002). Marine debris ingestion in loggerhead sea turtles, *Caretta caretta*, from the Western Mediterranean. *Marine Pollution Bulletin, 44*, 211-216.

Turtle Expert Working Group. (2007). *An Assessment of the Leatherback Turtle Population in the Atlantic Ocean*. (NOAA Technical Memorandum NMFS-SEFSC-555, pp. 116) U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service and Southeast Fisheries Science Center.

U.S. Department of the Navy. (1996). *Environmental Assessment of the Use of Selected Navy Test Sites for Development Tests and Fleet Training Exercises of the MK-46 and MK 50 Torpedoes* [Draft report]. Program Executive Office Undersea Warfare, Program Manager for Undersea Weapons.

U.S. Department of the Navy. (2003a). Final Environmental Assessment Inner Apra Harbor Maintenance Dredging Guam. Prepared by Belt Collins Hawaii Ltd.

U.S. Department of the Navy. (2003b). Integrated Natural Resources Management Plan Farallon De Medinilla and Tinian Military Lease Areas Commonwealth of the Northern Mariana Islands Plan Duration: FY03-12. (pp. 359). Prepared by P. Helber Hastert & Fee. Prepared for Commander, U.S. Naval Forces Marianas.

U.S. Department of the Navy. (2004). Year 2003 Assessment of Marine and Fisheries Resources Farallon De Medinilla, Commonwealth of the Northern Mariana Islands Final Report. (Contract No. N62742-02-D-1802 Delivery Order No. 002, pp. 48). Prepared by T. E. Company. Prepared for Pacific Division, Naval Facilities Engineering Command.

U.S. Department of the Navy. (2005). Year 2004 Assessment Marine and Fisheries Resources Second Working Copy Farallon De Medinilla Commonwealth of the Northern Mariana Islands. (pp. 68). Prepared by T. E. Company.

U.S. Department of the Navy. (2010). Mariana Islands Range Complex Final Environmental Impact Statement/Overseas Environmental Impact Statement. (pp. 952).

U.S. Department of the Navy. (2012). Pacific Navy Marine Species Density Database. NAVFAC Pacific Technical Report, Makalapa, Hawaii.

U.S. Department of the Navy. (2012b). Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis. Space and Naval Warfare (SPAWAR) Systems Center Pacific, San Diego.

Urick, R. (1983). Principles of Underwater Sound, Principles of Underwater Sound for Engineers (3rd ed.). Los Altos Hills, California: Peninsula Publishing.

van Dam, R. P. & Diez, C. E. (1996). Diving behavior of immature hawksbills (*Eretmochelys imbricata*) in a Caribbean cliff-wall habitat. *Marine Biology, 127*, 171-178.

Valverde, R. A., Orrego, C. M., Tordoir, M. T., Gómez, F. M., Solís, D. S., Hernández, R. A., Gómez, G. B., Brenes, L. S., Baltodano, J. P., Fonseca, L. G. & Spotila, J. R. (2012). Olive Ridley Mass Nesting Ecology and Egg Harvest at Ostional Beach, Costa Rica. Chelonian Conservation and Biology, 11(1), 1-11.

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

Wallace, B. P., DiMatteo, A. D., Hurley, B. J., Finkbeiner, E. M., Bolten, A. B., Chaloupka, M. Y., Hutchinson, B. J., Abreu-Grobois, F. A., Amorocho, D., Bjorndal, K. A., Bourjea, J., Bowen, B. W., Dueñas, R. B., Casale, P., Choudhury, B. C., Costa, A., Dutton, P. H., Fallabrino, A., Girard, A., Girondot, M., Godfrey, M. H., Hamann, M., López-Mendilaharsu, M., Marcovaldi, M. A., Mortimer, J. A., Musick, J. A., Nel, R., Pilcher, N. J., Seminoff, J. A., Troëng, S., Witherington, B. & Mast, R. B. (2010). Regional Management Units for Marine Turtles: A Novel Framework for Prioritizing Conservation and Research across Multiple Scales. PLoS ONE 5(12): e15465.

Wallace, B. P., Lewison, R. L., McDonald, S. L., McDonald, R. K., Kot, C. Y., Kelez, S., Crowder, L. B. (2010). Global patterns of marine turtle bycatch. *Conservation Letters, xx*, 1-12.

Wallace, B. P., Williams, C.L., Paladino, F.V., Morreale, S.J. Lindstrom, R.T., & Spotila, J.R. (2005). Bioenergetics and diving activity of internesting leatherback turtles *Dermochelys coriacea* at Parque Nacional Marino Las Baulas, Costa Rica. The Journal of Experimental Biology, 208, 3873-3884.

Ward W.D., Glorig A. & Sklar D.L. (1958). Dependence of temporarty threshold shift at 4 kc on intensity and time. The Journal of the Acoustical Society of America 30(10): 944-954.

Ward W.D., Glorig A. & Sklar D.L. (1959). Temporary threshold shift from octave-band noise: Applications to damage risk criteria. The Journal of the Acoustical Society of America 31(4): 522-528.

Wartzok, D. & Ketten, D. R. (1999). Marine Mammal Sensory Systems J. E. Reynolds III and S. A. Rommel (Eds.), *Biology of Marine Mammals* (pp. 117-175). Washington, D.C.: Smithsonian Institution Press.

Weir, C. R. (2007). Observations of Marine Turtles in Relation to Seismic Airgun Sound off Angola. *Marine Turtle Newsletter* 116: 17-20.

Wever, E. G. (1978). The Reptile Ear: Its Structure and Function (pp. 1024). Princeton, NJ: Princeton University Press.

Whiting, S.D., Long, J.L., Coyne, M. (2007). Migration routes and foraging behaviour of olive ridley turtles Lepidochelys olivacea in northern Australia. Endangered Species Research, 3, 1-9.

Witham, R. (1980). The "lost year" question in young sea turtles. *American Zoologist, 20*(3), 525-530.

Witherington, B. & Hirama, S. (2006). Sea turtles of the epi-pelagic sargassum drift community. In M. Frick, A. Panagopoulou, A. F. Rees and K. Williams (Eds.), *Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation* (Abstract, pp. 209). Athens, Greece: International Sea Turtle Society.

Witherington, B. E. (1992). Behavioral responses of nesting sea turtles to artificial lighting. *Herpetologica, 48*(1), 31-39.

Witherington, B. E. (1994). Flotsam, jetsam, post-hatchling loggerheads, and the advecting surface smorgasbord. Pages 166-168 in K. A. Bjorndal, A. B. Bolten, D. A. Johnson, and P. J. Eliazar, compilers. Proceedings of the 14th annual symposium on sea turtle biology and conservation. Technical memorandum NMFS-SEFSC-351. National Oceanic and Atmospheric Administration, Miami, Florida.

Witherington, B. E. & Bjorndal, K. A. (1991). Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles, *Caretta caretta*. *Biological Conservation, 55*(2), 139-149

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

Witt, M.J., Baert, B., Broderick, A.C., Formia, A., Fretey, J., Alain, Gibudi, Mounguenhui, G.A.M., Moussounda, C., Ngouessono, S., Parnell, R.J., Roumet, D. Sounguet, G., Verhage, B., Zogo, A., and Godely, B.J. (2009). Aerial surveying of the world's largest leatherback turtle rookery: A more effective methodology for large-scale monitoring. *Biological Conservation*, 142, 1719–1727

Witzell, W. N. (1983). *Synopsis of Biological Data on the Hawksbill Turtle* Eretmochelys imbricata *(Linnaeus, 1766)*. (FAO Fisheries Synopsis 137, pp. 78). Rome, Italy: United Nations Environment Programme, Food and Agriculture Organization of the United Nations.

Wood, F. and Wood, J. (1993). Release and Recapture of Captive Reared Green Sea Turtle, (*Chelonia mydas*) in the Waters Surrounding Grand Cayman. *Herpetological Journal*, Vol. 3, pp. 84-89.

Wyneken, J. (2001). The Anatomy of Sea Turtles [Technical Memorandum]. (NOAA Technical Memorandum NMFS-SEFSC-470, pp. 172) U.S. Department of Commerce.

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

Yelverton, J. T., Richmond, D. R., Fletcher, E. R. & Jones, R. K. (1973). Safe distances from underwater explosions for mammals and birds [Defense Nuclear Agency Report]. (DNA 3114T, pp. 66). Albuquerque, New Mexico: Lovelace Foundation for Medical Education and Research.

Yelverton, J. T., Richmond, D. R., Hicks, W., Saunders, K. & Fletcher, E. R. (1975). The Relationship Between Fish Size and Their Response to Underwater Blast Defense Nuclear Agency (Ed.), [Topical Report]. (DNA 3677T, pp. 40). Washington, D.C.: Lovelace Foundation for Medical Education and Research.

Yntema, C. L., and Mrosovsky, N. (1980). Sexual Differentiation in Hatchling Loggerheads (Caretta caretta) Incubated at Different Controlled Temperatures. *Herpetologica*, Vol. 36, No. 1, pp. 33-36.

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

Zenteno, M., Herrera, M., Barragan, A. & Sarti, L. (2008). Impact of Different Kinds and Times of Retention in Olive Ridley's (Lepidochelys olivacea) Hatchlings in Blood Glucose Levels. Presented at the Twenty-Seventh Annual Symposium on Sea Turtles, Myrtle Beach, South Carolina.

Zug, G. R., Chaloupka, M. & Balazs, G. H. (2006). Age and growth in olive ridley sea turtles (*Lepidochelys olivacea*) from the North-central Pacific: a skeletochronological analysis. *Marine Ecology, 27*, 263-270.

This Page Intentionally Left Blank