Final
Environmental Impact Statement/Overseas Environmental Impact Statement
Atlantic Fleet Training and Testing

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3.6 Fishes

FISHES SYNOPSIS

The United States Department of the Navy (Navy) considered all potential stressors that fishes could potentially be exposed to from the Proposed Action. The following conclusions have been reached for the Preferred Alternative (Alternative 1):

- Acoustics: The use of sonar and other transducers, air guns, pile driving, vessel noise, aircraft noise, and weapons noise could result in impacts on fishes in the Study Area. Some sonars and other transducers, vessel noise, and weapons noise could result in hearing loss, masking, physiological stress, or behavioral reactions. Aircraft noise would not likely result in impacts other than brief, mild behavioral responses in fishes that are close to the surface. Air guns and pile driving have the potential to result in the same effects in addition to mortality or injury. Most impacts, such as masking or behavioral reactions, are expected to be temporary and infrequent as most activities involving acoustic stressors would be at low levels of noise, temporary, localized, and infrequent. More severe impacts such as mortality or injury could lead to permanent or long-term consequences for individuals but, overall, long-term consequences for fish populations are not expected.
- Explosives: The use of explosives could result in impacts on fishes within the Study Area. Sound and energy from explosions is capable of causing mortality, injury, hearing loss, masking, physiological stress, or behavioral responses. The time scale of individual explosions is very limited, and training and testing activities involving explosions are dispersed in space and time, therefore, repeated exposure of individual fishes are unlikely. Most effects such as hearing loss or behavioral responses are expected to be short term and localized. More severe impacts such as mortality or injury could lead to permanent or long-term consequences for individuals but, overall, long-term consequences for fish populations are not expected.
- Energy: The use of electromagnetic devices may elicit brief behavioral or physiological stress responses only in those exposed fishes with sensitivities to the electromagnetic spectrum. This behavioral impact is expected to be temporary and minor. Similar to regular vessel traffic that is continuously moving and covers only a small spatial area during use, electromagnetic fields would be continuously moving and cover only a small spatial area during use, so population-level impacts are unlikely.
- Physical Disturbance and Strike: Vessel strikes, in-water device strikes, military expended material strikes, and seafloor device strikes present a risk for collision with fishes, particularly near coastal areas, seamounts, and other bathymetric features where densities are higher. While the potential for physical disturbance and strikes of fishes can occur anywhere vessels are operated or training and testing activities occur, most fishes are highly mobile and have sensory capabilities which enable the detection and avoidance of vessels, expended materials, or objects in the water column or on the seafloor.

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FISHES SYNOPSIS

- Entanglement: Fishes could be exposed to multiple entanglement stressors associated with Navy training and testing activities. The potential for impacts is dependent on the physical properties of the expended materials and the likelihood that a fish would encounter a potential entanglement stressor and then become entangled in it. Physical characteristics of wires and cables, decelerators/parachutes, and biodegradable polymers, combined with the sparse distribution of these items throughout the Study Area, indicates a very low potential for fishes to encounter and become entangled in them. Because of the low numbers of fish potentially impacted by entanglement stressors, population-level impacts are unlikely.
- Ingestion: The likelihood that expended items would cause a potential impact on a given fish species depends on the size and feeding habits of the fish and the rate at which the fish encounters the item and the composition of the item. Military expended materials from munitions present an ingestion risk to fishes that forage in the water column and on the seafloor. Military expended materials other than munitions present an ingestion risk for fishes foraging at or near the surface while these materials are buoyant, and on the seafloor when the materials sink. Because of the low numbers of fish potentially impacted by ingestion stressors, population-level impacts are unlikely.
- Secondary: Effects on sediment or water quality would be minor, temporary, and localized and could have short-term, small-scale secondary effects on fishes; however, there would be no persistent or large-scale effects on the growth, survival, distribution, or population-level impacts of fishes.

3.6.1 Introduction

This section analyzes the potential impacts of the Proposed Action on fishes found in the Study Area. Endangered Species Act (ESA) species that occur in the Study Area are discussed in Section 3.6.2.2 and taxonomic groupings are discussed in Section 3.6.2.3. The complete analysis of environmental consequences is in Section 3.6.3 (Environmental Consequences) and the potential impacts of the Proposed Action on marine fish species are summarized in Section 3.6.4 (Summary of Potential Impacts on Fishes).

For this Environmental Impact Statement (EIS)/Overseas EIS (OEIS), marine fishes are evaluated as groups of species characterized by distribution, morphology (body type), or behavior relevant to the stressor being evaluated. Activities are evaluated for their potential effects on the marine fishes in the Study Area that are listed, proposed, or candidate species under the ESA, as well as other fishes in the Study Area generally by major marine fish groupings. Fishes are not distributed uniformly throughout the Study Area but are closely associated with a variety of habitats. Some species, such as large sharks, salmon, tuna, and billfishes, range across thousands of square miles. Other species, such as gobies and most reef fish, generally have small home ranges and restricted distributions (Helfman et al., 2009). The early life stages (e.g., eggs and larvae) of many fishes may be widely distributed even when the adults have relatively small ranges. The movements of some open-ocean species may never overlap with coastal fishes that spend their lives within several hundred feet of the shore. The distribution and specific habitats in which an individual of a single fish species occurs may be influenced by its life stage, size, sex, reproductive condition, and other factors. Approximately 78 percent of all marine fish species occur in waters less than 200 meters (m) deep and in close association with land, while 13 percent are associated with the open ocean (Moyle & Cech, 2004).

3.6.2 Affected Environment

Three subsections are included in this section. General background information is given in Section 3.6.2.1 (General Background), which provides brief summaries of habitat use, movement and behavior, and threats that affect or have the potential to affect fishes within the Study Area. Protected species listed under the ESA are described in Section 3.6.2.2 (Endangered Species Act-Listed Species). General taxonomic groupings of fishes not listed under the ESA are briefly reviewed in Section 3.6.2.3 (Species Not Listed Under the Endangered Species Act).

3.6.2.1 General Background

Fishes are the most numerous and diverse of the major vertebrate groups (Moyle & Cech, 2004). It is estimated that there are currently over 34,000 species of fish worldwide (Eschmeyer & Fong, 2017), with greater than half that number of species inhabiting the oceans.

Many factors impact the abundance and distribution of marine fishes in the seven Large Marine Ecosystems (West Greenland Shelf, Newfoundland-Labrador Shelf, Scotian Shelf, Northeast United States (U.S.) Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea) and three open ocean areas (Labrador Sea, North Atlantic Subtropical Gyre, and Gulf Stream Current) in the Study Area. The distribution of fish species in the Study Area is influenced primarily by temperature, salinity, pH, physical habitat, ocean currents, and latitudinal gradients (Helfman et al., 2009; Macpherson, 2002). In general terms, the coastal-centered Large Marine Ecosystems support a greater diversity of coastal species, while the open ocean areas support a lower diversity of oceanic and deep-sea species (Helfman et al., 2009). The warm waters of the Loop Current in the Gulf of Mexico promote the dispersal of tropical species from the Caribbean Sea into the Northern Gulf of Mexico (Shulman, 1985). The circulation patterns of the Gulf Stream and the North Atlantic Subtropical Gyre also influence species distributions, particularly near Bermuda and Cape Hatteras, where the northernmost occurrences of sizable tropical fish assemblages are found (Love & Chase, 2007; Moyle & Cech, 2004). The Gulf Stream, described in Section 3.0.2 (Ecological Characterization of the Study Area), carries warm water to northern latitudes, where these areas can support subtropical species. For example, approximately half of the species occurrences in the Gulf of Maine are considered warm-water fish (Moyle & Cech, 2004), although some of these are sporadic or rare.

Marine fishes can be broadly categorized by their distributions within the water column or habitat usage. Moyle and Cech (2004) define the major marine habitat categories as estuaries, coastal habitats, reefs, epipelagic zone, deep sea, and the Polar regions. In the Study Area, the major habitat categories include all of the aforementioned except the Polar regions. Many marine fishes that occur in the Study Area are demersal species associated with nearshore coastal reefs or are more oceanic and live in surface waters (pelagic) further offshore (Schwartz, 1989). The highest number and diversity of fishes typically occur where the habitat has structural complexity (reef systems, continental slopes, deep canyons), biological productivity (areas of nutrient upwelling), and a variety of physical and chemical conditions (water flow, nutrients, dissolved oxygen, and temperature) (Bergstad et al., 2008; Helfman et al., 2009; Moyle & Cech, 2004; Parin, 1984). Some of the marine fishes that occur in the coastal zone migrate between marine and freshwater habitats (Helfman et al., 2009). Other distribution factors, including predator/prey relationships, water quality, and refuge (e.g., physical structure or vegetation cover) operate on more regional or local spatial scales (Reshetiloff, 2004). Also, fishes may move among habitats throughout their lives based on changing needs during different life stages (Schwartz, 1989).

Many habitat and geographic factors impact the distribution of fishes within the Study Area—including within range complexes, operating areas (OPAREAs), inshore waters, ports/shipyards, and testing ranges. In the Gulf of Mexico portion of the Study Area, water temperature, seafloor (benthic) habitat, and geographic location appear to be the primary factors, while in the Atlantic Ocean portion, latitudinal changes, temperature, and depth seem to be the most important factors influencing species distribution (Gordon, 2001; Love & Chase, 2007; Macpherson, 2002). Each major habitat type in the Study Area (e.g., coral reef, hard bottom, soft bottom, and beds of aquatic vegetation) supports an associated fish community with the number of species increasing with decreasing latitude (transition from north to south). However, this pattern is not as clearly defined for wide-ranging migratory open-ocean species (Macpherson, 2002). The specific characteristics of the wide diversity of habitat and biotic species that make up these habitat types within the Study Area are discussed in Section 3.3 (Vegetation), Section 3.4 (Invertebrates), and Section 3.5 (Habitats).

Some fish species in the United States are protected under the ESA and are managed by either the U.S. Fish and Wildlife Service (USFWS) or National Marine Fisheries Service (NMFS). The recreational and commercial fisheries are managed within a framework of overlapping international, federal, state, interstate, and tribal authorities. Individual states and territories generally have jurisdiction over fisheries located in marine waters within 3 nautical miles (NM) of their coast, except for Texas, the Gulf Coast of Florida, and Puerto Rico, which have jurisdiction out to 9 NM. Federal jurisdiction includes fisheries in marine waters inside the U.S. Exclusive Economic Zone. The area stretches from the outer boundary of state waters out to 200 NM offshore of any United States coastline, except where intersected closer than 200 NM by the Exclusive Economic Zone of bordering countries.

The Magnuson-Stevens Fishery Conservation and Management Act and Sustainable Fisheries Act led to the formation of eight regional fishery management councils that coordinate with NMFS to manage and conserve certain fisheries in federal waters. Together with NMFS, the councils maintain fishery management plans for species or species groups comprised of fish, invertebrates, and vegetation to regulate commercial and recreational harvest within their geographic regions. The Study Area overlaps with the jurisdiction of five regional fishery management councils, as well as the range of the highly migratory species (e.g., sharks, billfishes, swordfishes, and tunas), which are managed directly by NMFS.

- **New England Fishery Management Council** includes Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut.
- **Mid-Atlantic Fishery Management Council** includes New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and North Carolina (from its northern border to Cape Hatteras).
- **South Atlantic Fishery Management Council** includes North Carolina (from Cape Hatteras to its southern border), South Carolina, Georgia, and the east coast of Florida.
- **Gulf of Mexico Fishery Management Council** includes west coast of Florida, Alabama, Mississippi, Louisiana, and Texas.
- **Caribbean Fishery Management Council** includes the Commonwealth of Puerto Rico and the U.S. Virgin Islands.
- **NMFS, Office of Sustainable Fisheries** includes all federally managed waters in the Northwestern Atlantic Ocean and the Gulf of Mexico where highly migratory species occur.

3.6.2.1.1 Habitat Use

Fishes inhabit most of the world's oceans, from warm shallow coastal habitat to cold deep-sea waters, and are found on the surface, in the water column, and at the bottom of the seven Large Marine Ecosystems (West Greenland, Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea) and open ocean areas (Labrador Current, Gulf Stream, and North Atlantic Gyre) in the Study Area. The description of habitat use in this section pertains to common fishes found in the different habitats. The abiotic (non-living) components of all habitat types are addressed in Section 3.5 (Habitats), habitat-forming invertebrates (e.g., coral, sponges, etc.) are covered in Section 3.4 (Invertebrates), and marine vegetation components are discussed in Section 3.3 (Vegetation).

Fish distribution is restricted by biotic factors (competition or predation) or by abiotic components, such as temperature, salinity, dissolved oxygen, and pH or by that describe the potential range of environmental conditions a species can inhabit in the absence of predators and competitors. A species can be excluded from habitat otherwise suitable for it by competitors, predators, parasites, or lack of suitable prey (Moyle & Cech, 2004). For example, Catano et al. (2015) found that a loss of corals and the resulting decline in structural complexity, as well as management efforts to protect reefs, could alter the territory dynamics and reproductive potential of important herbivorous fish species.

Estuaries are comprised of brackish water, where freshwater mixes with saltwater to form transitional environments between rivers and the ocean. The fluctuating nature of the estuarine environment means that the fishes inhabiting or transiting through expend considerable amounts of energy adjusting to the changing conditions. Fishes found in estuaries are of five broad types: (1) freshwater (e.g., catfishes [*Ictalurus* spp.]), (2) diadromous species that spend part of their lives in freshwater and part of their lives in saltwater (e.g., young American shad, striped bass, Atlantic sturgeon, and Gulf sturgeon), (3) true estuarine (e.g., white perch [*Morone americana*]), (4) marine species that use estuaries but do not necessarily need them (e.g., American plaice [*Hippoglossoides platessoides*]), and (5) marine species that need estuaries for at least one stage of their lives (e.g., croakers [*Micropogonias* and *Leistomus* spp.]) (Moyle & Cech, 2004). Estuaries are primarily composed of soft bottom (e.g., sandy and mudflats) and many contain a variety of benthic habitat types such as seagrass beds and oyster reefs.

Marine and diadromous fishes inhabit the diverse coastal habitats on or near the edges of the continents, from the intertidal regions to the edge of the continental shelf (Moyle & Cech, 2004). The most abundant and conspicuous types of coastal habitats are hard bottom (e.g., rocky bottom which can include shell beds), soft bottom (e.g., sand, mud, silt), submerged aquatic vegetation (e.g., mangroves, salt marshes, seagrass beds, macroalgae beds), and floating macroalgae (e.g., *Sargassum*). Each of these coastal habitats has distinct types of fishes associated with it. In the Study Area, common fishes inhabiting the hard bottom habitat type include, but are not limited to gobies (Gobiidae), drums (Sciaenidae), seabasses (Serranidae), groupers (Epinephelidae), snappers (Lutjanidae), and sculpins (Cottidae), while flounder (Bothidae and Paralichthyidae) and stingrays (Dasyatidae) are found on soft bottoms. Grunts (Haemulidae) and a wide variety of other fishes are common inhabitants of submerged aquatic vegetation habitat.

Somewhere between 30 percent and 40 percent of all fish species are associated with hard bottom habitats (tropical and subtropical) such as reefs, and anywhere from 250 to 2,200 species are likely to be found in, on, or near a major complex of reefs (Moyle & Cech, 2004). Coral reef habitats are found between latitudes 30° North (N) and 30° South (S) in shallow water (usually less than 164 feet [ft.]) that is warm enough to support the growth of corals and clear enough to allow photosynthesis at moderate depths. However, some mesophotic and deepwater corals such as *Lophelia pertusa* has been found on relatively shallow reefs (180 to 250 m) off northeastern Florida (Ross et al., 2015). Most reef habitats are surrounded by nutrient-poor oceanic waters. Examples of some specialized carnivore fishes include flounders, coronetfishes (Fistularidae), and needlefishes (Belonidae). Compared to the total number of species of carnivorous fishes that inhabit low-latitude coral reefs, the number of herbivores is small (20 percent), but they are often the most noticeable fishes. Damselfishes (Pomacentridae), parrotfishes (Labridae), and surgeonfishes (Acanthuridae) are examples of herbivorous fishes found in reef habitat (Moyle & Cech, 2004). In the Study Area, commonly recognized reef fishes include butterfly fishes (Chaetodontidae), puffers (Tetraodontidae), tangs (Acanthuridae), triggerfishes (Balistidae), and wrasses (Labridae).

The upper 656 ft. (200 m) of the ocean is termed the photic or epipelagic zone (Moyle & Cech, 2004). Sunlight penetrates sufficiently to support the growth of phytoplankton and macroalgae. The area between 656 and 3,281 ft. (200 m and 1,000 m) is referred to as the mesopelagic zone, where light penetration is minimal (Moyle & Cech, 2004). Below the mesopelagic zone is the bathypelagic or aphotic zone, where sunlight does not penetrate. The lack of habitat complexity limits the number of fish species that inhabit the Epipelagic Zone. Less than 2 percent of all fish species inhabit the poor nutrient waters, with most occurring in the upper 328 ft. of the water column, where light can penetrate and permit phytoplankton growth and visual predators to see their prey. Epipelagic fishes are divided for convenience into nearshore and oceanic groups. Nearshore epipelagic fishes are overall the most commercially valuable group of fishes to humans because they typically occur in large schools, such as herring (Clupeidae) and anchovies (Engraulidae), or are particularly favored as food, such as tunas (Scombridae) and salmon (Salmonidae). Predators on nearshore epipelagic fishes include billfishes and swordfishes (Xiphiidae), sharks (Carcharhinidae), and others. Oceanic epipelagic spend their entire life cycle either free swimming or can be associated with drifting macroalgae (*Sargassum* spp.) (Moyle & Cech, 2004). In the Study Area, examples of epipelagic open ocean fishes include sharks, tunas, billfishes and swordfishes, sauries (Scomberesocidae), and ocean sunfish (Molidae), plus the commensal remoras (Echeneidae).

Mesopelagic habitats reside below the well-lighted, well-mixed epipelagic zone. Between 400 ft. and 3,280 ft. in depth, light gradually fades to extinction, and the water temperatures decreases to 39° Fahrenheit (°F). Below 3,280 ft., bathypelagic habitats are characterized by complete darkness, low temperatures, low nutrients, low dissolved oxygen, and great pressure. This environment is the most extensive aquatic habitat on earth. The vastness of the deep-sea habitat, coupled with its probable stability through geological time, has led to the development of a diverse fish community, which accounts for 11 percent of all recorded fish species in the oceans. Lanternfishes (Myctophidae), with about 240 species, are an important group of mesopelagic deep sea fishes in terms of diversity, distribution, and numbers of individuals (Helfman et al., 2009). These species make up a large fraction of the deep scattering layer, so called because the sonic pulses of a sonar can reflect off the millions of swim bladders, often giving the impression of a false bottom (Moyle & Cech, 2004). Generally, deep-sea fishes are divided into two groups, those that are found in the water column and others associated with the seafloor. In the Study Area, the cookie cutter shark (Dalatiidae), fangtooths (Anoplogastridae), hatchetfishes (Sternoptychidae), and lanternfishes (Myctophidae) inhabit the water column while the seafloor is inhabited with grenadiers or rattails (Macrouridae), hagfishes (Myxinidae), hakes (Merlucciidae), and rays (Rajidae).

Some fishes use one habitat type over their entire life cycle, while others associate with different habitat types by life stage. Anadromous fishes such as sturgeon (Acipenseridae) and salmon hatch and rear in freshwater rivers as larvae and early juveniles and inhabit estuaries as they transition into the late-juvenile and early sub-adult life stages before entering the ocean to mature into adults. Many other marine fishes inhabit the water column as larvae and settle onto soft bottom habitat as juveniles and remain there as adults (flatfishes). The oceanic Atlantic bluefin tuna (*Thunnus thynnus*) provides an example of a species closely connected to one habitat category across their life cycle. By comparison, the Atlantic salmon (*Salmo salar*) and American shad (*Alosa sapidissima*) inhabit wide ranges of salinity and water depths that vary by season and age.

3.6.2.1.2 Movement and Behavior

Fishes exhibit a rich array of sophisticated behavior (Meyer et al., 2010). Fishes have been shown to cooperate in a variety of ways during foraging, navigation, reproduction, and predator avoidance (Fitzpatrick et al., 2006; Huntingford et al., 2006). Some examples of the common types of behavior exhibited by fishes include movement or migration, schooling, feeding, and resting (Moyle & Cech, 2004).

Migratory behavior consists of mass movements from one place to another and can range in occurrence from daily to seasonal, depending on the species. Tunas, salmon, and eels migrate thousands of miles in short periods of time (e.g., a few months). Daily or seasonal migrations are typically for feeding and/or predator avoidance and can also be referred to as movement patterns. Some common movement patterns include coastal migrations, open ocean migrations, onshore/offshore movements, vertical water column movements, and life stage related migrations (e.g., eggs and larvae as part of the plankton/nekton). Migratory behavior occurs in response to changing environmental conditions, particularly temperature, or the movement and abundance of food organisms. The destinations of migratory events are often feeding or reproductive grounds. Many fishes have the ability to find their way back to a “home” area and some species use olfactory and visual cues, as well as or from chemicals released by the other fishes to return home (Moyle & Cech, 2004). Highly migratory species such as hammerhead shark (*Sphyrna* spp.), basking shark (*Cetorhinus maximus*), and swordfish (*Xiphias gladius*), may move across thousands of miles of open ocean. Other migratory species such as the Atlantic salmon and Atlantic sturgeon exhibit seasonal movement patterns throughout coastal continental shelf waters and beyond.

A shoal is defined as any group of fishes that remain together for social reasons, while a school is a polarized, synchronized shoal (Moyle & Cech, 2004), often swimming together in tight formations. Schools can change shape when traveling, feeding, resting, or avoiding predators. Vision and the lateral line system (defined below in Section 3.6.2.1.3, Hearing and Vocalization) play roles in assisting schooling by allowing fish to visually orientate to one another and also sense water movements when visibility is reduced. Schooling may also be beneficial in terms of reproduction since little energy has to be expended to find a mate when sexes school together (Moyle & Cech, 2004).

Feeding behavior of fishes is influenced by many factors, including characteristics of the environment, the predators, and prey. When food is scare, fish have been observed to capture prey items of all sizes for which there is likely to be a net gain of energy for the fish, however, when food is abundant, fish will preferentially seek the prey item that produces the most energy for the least amount of effort. The body shape of a fish species, specifically the mouth, reflects the general method of feeding. Many fishes must swallow their prey whole and have specialized mouth sizes for their prey depending on the prey’s shape and fin spines (Price et al., 2015). Fishes with their mouth on the underside of their body (e.g., sturgeon, rays, skates, etc.) are typically bottom feeders, while fishes with their mouths near the top of their head (e.g., mullets, halfbeaks, etc.) are typically surface feeders. Fishes that typically feed in the water column, which includes most species, have mouths that are centered in their head. Common types of feeding behavior include ambushing, drift feeding, and filter feeding and fishes may regularly switch between two or more modes of feeding behavior depending on the abundance of prey (Moyle & Cech, 2004).

3.6.2.1.3 Hearing and Vocalization

All fishes have two sensory systems which can detect sound in the water: the inner ear, which functions similarly to the inner ear in other vertebrates, and the lateral line, which consists of a series of receptors along the body of a fish (Popper & Schilt, 2008). The lateral line system is sensitive to external particle motion arising from sources within a few body lengths of the animal. The lateral line detects particle motion at low frequencies from below 1 hertz (Hz) up to at least 400 Hz (Coombs & Montgomery, 1999; Hastings & Popper, 2005; Higgs & Radford, 2013; Webb et al., 2008). Generally, the inner ears of fish contain three dense otoliths (i.e., small calcareous bodies) that sit atop many delicate mechanoelectric hair cells within the inner ear of fishes, similar to the hair cells found in the mammalian ear. Sound waves in water tend to pass through the fish's body, which has a composition similar to water, and vibrate the otoliths. This causes a relative motion between the dense otoliths and the surrounding tissues causing a deflection of the hair cells, which is sensed by the nervous system.

Although a propagating sound wave contains pressure and particle motion components, particle motion is most significant at low frequencies (up to at least 400 Hz) and is most detectible at high sound pressures or very close to a sound source. The inner ears of fishes are directly sensitive to acoustic particle motion rather than acoustic pressure (acoustic particle motion and acoustic pressure are discussed in Appendix D, Acoustic and Explosive Concepts). Historically, studies that have investigated hearing in, and effects to, fishes have been carried out with sound pressure metrics. Although particle motion may be the more relevant exposure metric for many fish species, there is little data available that actually measures it due to a lack in standard measurement methodology and experience with particle motion detectors (Hawkins et al., 2015; Martin et al., 2016). In these instances, particle motion can be estimated from pressure measurements (Nedelec et al., 2016a).

Some fishes possess additional morphological adaptations or specializations that can enhance their sensitivity to sound pressure, such as a gas-filled swim bladder (Astrup, 1999; Popper & Hastings, 2009b; Popper & Fay, 2011). The swim bladder can enhance sound detection by converting acoustic pressure into localized particle motion, which may then be detected by the inner ear (Radford et al., 2012). Fishes with a swim bladder generally have better sensitivity and can detect higher frequencies than fishes without a swim bladder (Popper & Hastings, 2009a; Popper et al., 2014). In addition, structures such as gas-filled bubbles near the ear or swim bladder, or even connections between the swim bladder and the inner ear, also increase sensitivity and allow for high-frequency hearing capabilities and better sound pressure detection.

Although many researchers have investigated hearing and vocalizations in fish species (Ladich & Fay, 2013; Popper et al., 2014), hearing capability data only exist for just over 100 of the currently known 34,000 marine and freshwater fish species (Eschmeyer & Fong, 2016). Therefore, fish hearing groups are defined by species that possess a similar continuum of anatomical features which result in varying degrees of hearing sensitivity (Popper & Hastings, 2009b; Popper & Fay, 2011). Categories and descriptions of hearing sensitivities are further defined in this document (modified from Popper et al., 2014) as the following:

- Fishes without a swim bladder – hearing capabilities are limited to particle motion detection at frequencies well below 1 kilohertz (kHz).
- Fishes with a swim bladder not involved in hearing – species lack notable anatomical specializations and primarily detect particle motion at frequencies below 1 kHz.
- Fishes with a swim bladder involved in hearing – species can detect frequencies below 1 kHz and possess anatomical specializations to enhance hearing and are capable of sound pressure detection up to a few kHz.
- Fishes with a swim bladder and high-frequency hearing – species can detect frequencies below 1 kHz and possess anatomical specializations and are capable of sound pressure detection at frequencies up to 10 kHz to over 100 kHz.

Data suggest that most species of marine fish either lack a swim bladder (e.g., sharks and flatfishes) or have a swim bladder not involved in hearing and can only detect sounds below 1 kHz. Some marine fishes (clupeiforms) with a swim bladder involved in hearing are able to detect sounds to about 4 kHz (Colleye et al., 2016; Mann et al., 2001; Mann et al., 1997). One subfamily of clupeids (i.e., Alosinae) can detect high- and very high-frequency sounds (i.e., frequencies from 10 to 100 kHz, and frequencies above 100 kHz, respectively), although auditory thresholds at these higher frequencies are elevated and the range of best hearing is still in the low-frequency range (below 1 kHz) similar to other fishes. Mann et al. (1997; 1998) theorize that this subfamily may have evolved the ability to hear relatively high sound levels at these higher frequencies in order to detect echolocations of nearby foraging dolphins. For fishes that have not had their hearing tested, such as deep sea fishes, the suspected hearing capabilities are based on the structure of the ear, the relationship between the ear and the swim bladder, and other potential adaptations such as the presence of highly developed areas of the brain related to inner ear and lateral line functions (Buran et al., 2005; Deng et al., 2011, 2013). It is believed that most fishes have their best hearing sensitivity from 100 to 400 Hz (Popper, 2003).

Species listed under the ESA within the Study Area include the Atlantic salmon (*Salmo salar*), shortnose sturgeon (*Acipenser brevirostrum*), Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), Gulf sturgeon (*Acipenser oxyrinchus desotoi*), smalltooth sawfish (*Pristis pectinata*), scalloped hammerhead shark (*Sphyrna lewini*), Nassau grouper (*Epinephelus striatus*), giant manta ray (*Manta birostris*) and the oceanic whitetip shark (*Carcharhinus longimanus*). As discussed above, most marine fishes investigated to date lack hearing capabilities greater than 1,000 Hz. This notably includes sturgeon and salmonid species that have a swim bladder that is not involved in hearing however, sturgeons and salmon species have only been tested to date up to about 600 Hz (Hawkins & Johnstone, 1978; Kane et al., 2010; Lovell et al., 2005; Meyer et al., 2010). Sawfish, rays and sharks are cartilaginous fishes (i.e., elasmobranchs) lacking a swim bladder. Available data suggest these species can detect sounds from 20 to 1,000 Hz, with best sensitivity at lower ranges (Casper et al., 2003; Casper & Mann, 2006; Casper & Mann, 2009; Myrberg, 2001). Nassau groupers have a swim bladder that is not involved in hearing. As part of the family Epinephelidae, Nassau grouper may have a similar hearing range to the leopard coral grouper (*Plectropomus leopardus*), the larvae of which can detect sounds 100 to 2,000 Hz (Wright et al., 2008; Wright et al., 2010).

Some fishes are known to produce sound. Bony fishes can produce sounds in a number of ways and use them for a number of behavioral functions (Ladich, 2008, 2014). Over 30 families of fishes are known to use vocalizations in aggressive interactions, and over 20 families are known to use vocalizations in mating (Ladich, 2008). Sounds generated by fishes as a means of communication are generally below 500 Hz (Slabbekoorn et al., 2010). The air in the swim bladder is vibrated by the sound producing structures (often muscles that are integral to the swim bladder wall) and radiates sound into the water (Zelick et al., 1999). Sprague and Luczkovich (2004) calculated that silver perch, of the family sciaenidae, can produce drumming sounds ranging from 128 to 135 decibels referenced to 1 micropascal (dB re 1 µPa). Female midshipman fish apparently detect and locate the “hums” (approximately 90 to 400 Hz) of vocalizing males during the breeding season (McIver et al., 2014; Sisneros & Bass, 2003). Sciaenids produce a variety of sounds, including calls produced by males on breeding grounds (Ramcharitar et al., 2001), and a “drumming” call produced during chorusing that suggested a seasonal pattern to reproductive-related function (McCauley & Cato, 2000). Other sounds produced by chorusing reef fishes include “popping,” “banging,” and “trumpet” sounds; altogether, these choruses produce sound levels 35 dB above background levels, at peak frequencies between 250 and 1,200 Hz, and source levels between 144 and 157 dB re 1 µPa (McCauley & Cato, 2000).

3.6.2.1.4 General Threats

Fish populations can be influenced by various natural factors and human activities. There can be direct effects from disease or from commercial and recreational activities such as fishing, or indirect effects from reductions in prey availability or lowered reproductive success of individuals. Human-made impacts are widespread throughout the world’s oceans, such that very few habitats remain unaffected by human influence (Halpern et al., 2008a). Direct and indirect effects have shaped the condition of marine fish populations, particularly those species with large body size, late maturity ages, and/or low fecundity such as some elasmobranchs (e.g., scalloped hammerhead shark, smalltooth sawfish), sturgeon (e.g., Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon), and some reef fishes (e.g., Nassau grouper), making these species especially vulnerable to habitat losses and fishing pressure (Reynolds et al., 2005). Human-induced stressors (e.g., threats) can be divided into four components, which often act on fish populations simultaneously: habitat alteration, exploitation, introduction of non-native species, and pollution (Moyle & Cech, 2004). Climate change and its resulting effects on the marine environment is another stressor on fish populations (Roessig et al., 2004).

Coastal development, deforestation, road construction, dam development, water control structures, and agricultural activities are types of habitat alteration that can affect fishes and their environment. These activities may affect the water quality of the nearshore marine environment. Threats to fishes related to poor water quality are discussed in Section 3.6.2.1.4.1 (Water Quality). Threats from exploitation, including commercial and recreational fishing and other stressors, are addressed in Section 3.6.2.1.4.2 (Commercial and Recreational Activities). Fishes living in suboptimal habitat from habitat alteration and over exploitation due to fishing may be at increased risk of contracting diseases and acquiring parasites, and are covered in Section 3.6.2.1.4.3 (Disease and Parasites). The presence of an introduced species represents a major change in the native fish community, and this topic is discussed in Section 3.6.2.1.4.4 (Invasive Species). The threats to fish from oil spills, marine debris, and noise are covered in Section 3.6.2.1.4.1 (Water Quality). Climate change and its effects on fishes is addressed in Section 3.6.2.1.4.5 (Climate Change).

3.6.2.1.4.1 Water Quality

Parameters such as temperature, dissolved oxygen, salinity, turbidity, and pH define the water quality as a component of habitat quality for fishes. Some land-based activities can directly and indirectly impact water quality in rivers, estuaries, and in the coastal waters. Sediment from activities on land may be transported to the marine environment. Sediment can impact water quality by increasing turbidity and decreasing light penetration into the water column, as well as transport contaminants into the marine environment (Allen, 2006). Increases in sediment can decrease the survival and reproduction of plankton and have food web and ecosystem level effects.

Hypoxia (low dissolved oxygen concentration) is a major impact associated with poor water quality. Hypoxia occurs when waters become overloaded with nutrients such as nitrogen and phosphorus, which enter oceans from agricultural runoff, sewage treatment plants, bilge water, and atmospheric deposition. An overabundance of nutrients can stimulate algal blooms, resulting in a rapid expansion of microscopic algae (phytoplankton) and can cause anoxic events leading to fish kills (Corcoran et al., 2013). Over the last several decades, coastal regions throughout the world have experienced an increase in the frequency of algal blooms that are toxic or otherwise harmful. Commonly called red tides, these events are now grouped under the descriptor harmful algal blooms or HABs (Anderson et al., 2002). Harmful algal blooms can produce toxins, causing human illness and massive fish and other animal mortalities. The most common harmful algal bloom species in the Gulf of Mexico is *Karenia brevis* (National Oceanic and Atmospheric Administration, 2016c).

Pollution

Chemicals and debris are the two most common types of pollutants in the marine environment. Global oceanic circulation patterns result in the accumulation of a considerable amount of pollutants and debris scattered throughout the open ocean and concentrated in gyres and other places (Crain et al., 2009). Pollution initially impacts fishes that occur near the sources of pollution, but may also affect future generations from effects to reproduction and increase mortality across life stages.

Chemical pollutants in the marine environment that may impact marine fishes include organic pollutants (e.g., pesticides, herbicides, polycyclic aromatic hydrocarbons, flame retardants, and oil) and inorganic pollutants (e.g., heavy metals) (Pew Oceans Commission, 2003). High chemical pollutant levels in marine fishes may cause behavioral changes, physiological changes, or genetic damage (Goncalves et al., 2008; Moore, 2008; Pew Oceans Commission, 2003). Bioaccumulation is the net buildup of substances (e.g., chemicals or metals) in an organism from inhabiting contaminated habitat or sediment through the gills or skin, from ingesting food or prey containing the substance (Newman, 1998), or from ingestion of the substance directly (Moore, 2008).Bioaccumulation of pollutants (e.g., metals and organic pollutants) is also a concern to human health because people consume top predators with high pollutant loads.

Oil Spills

Groups of fish typically impacted by oil spills include surface-oriented or surface dwelling species, nearshore (within 3 NM of the shoreline) species, and species whose spawning time coincided with the timing of an oil spill (National Oceanic and Atmospheric Administration, 2010). Fishes can be impacted by the oil directly through the gills, or by consuming oil or oiled prey. Potentially harmful physiological effects to fishes from oil spills include reduced growth, enlarged livers, changes to heart and respiration rate, fin erosion, and reproductive impairment. The most damaging effects of oil on fish populations may be in harming eggs and larvae, because these stages are highly sensitive to oil at the surface, in the water column, or on the seafloor, and are subject to increased mortality and morphological deformities and impaired growth (Greer et al., 2012; Ingvarsdottir et al., 2012; National Oceanic and Atmospheric Administration, 2014). Discharges from ballast water and bilge water during routine ship operations and illegal dumping of solid waste are other sources of oil in the marine environment.

3.6.2.1.4.2 Commercial and Recreational Activities

Exploitation from commercial and recreational fishing is the single biggest cause of changes in fish populations and communities (Moyle & Cech, 2004). Historic and current overfishing largely contributed to the listing of ESA-protected marine fish species (Crain et al., 2009; Kappel, 2005). Overfishing of a resource results from legal and illegal fishing (poaching) and bycatch of resources in quantities above a sustainable level. By the end of 2015, 28 managed fish stocks in the U.S. were on the overfishing list and 38 stocks were on the overfished list, while the number of rebuilt fish stocks since 2000 increased to 39 (National Marine Fisheries Service, 2016a).

In recent decades, commercial fisheries have targeted the larger, predatory, and sometimes higher-priced fish species. Gradually, the fishing pressure will make the larger species more scarce, and fishing will move towards the smaller species, often causing negative implications for entire marine food webs (Pauly & Palomares, 2005). Other factors, such as fisheries-induced evolution and intrinsic vulnerability to overfishing, have been shown to reduce the abundance of some populations (Kauparinen & Merila, 2007). Fisheries-induced evolution describes a change in genetic composition of the population that results from intense fishing pressure, such as a reduction in the overall size and growth rates of fishes in a population. Intrinsic vulnerability describes certain life history traits (e.g., large body size, late maturity age, low growth rate, low offspring production) that result in a species being more susceptible to overfishing than others (Cheung et al., 2007).

Other threats from commercial industries to fishes include vessel strikes, sea farming, and energy production activities. Large commercial vessels (e.g., cruise liners, cargo ships) pose threats to large, slow-moving open ocean fishes while moving along the sea surface. Whale sharks (*Rhincodon typus*), basking sharks (*Cetorhinus maximus*), sturgeons, manta rays (*Manta* spp.), and ocean sunfish (*Mola mola*) are vulnerable to ship strikes (National Marine Fisheries Service, 2010d; Rowat et al., 2007; Stevens, 2007).

The threats of aquaculture operations on wild fish populations include reduced water quality, competition for food, predation by escaped or released farmed fishes, spread of disease and parasites, and reduced genetic diversity (Kappel, 2005). These threats become apparent when farmed fish escape and enter the natural ecosystem (Hansen & Windsor, 2006; Ormerod, 2003). The National Oceanic and Atmospheric Administration (2011) published the Marine Aquaculture Policy, which provides direction to enable the development of sustainable marine aquaculture.

Energy production and offshore activities associated with power-generating facilities results in direct and indirect injury and/or mortality of fishes. Injury and mortality sources include entrainment of eggs and larvae during water withdrawal and impingement of juveniles and adults (U.S. Environmental Protection Agency, 2004). Acoustic impacts from offshore wind energy development are additional sources of injury and mortality (Madsen et al., 2006). Williams et al. (2015) provide a comprehensive baseline of ecological data and associated predictive models and maps to help regulators, developers, and other stakeholders understand the implications of offshore wind energy development for wildlife populations in the mid-Atlantic United States.

Anthropogenic Noise

Anthropogenic noise is generated from a variety of sources, including commercial shipping, oil and gas exploration and production activities, commercial and recreational fishing (including fish-finding sonar, fathometers, and acoustic deterrent devices), recreational boating, whale watching activities and other marine transportation vessels such as ferries, marine and coastal development (i.e., construction of bridges, ferry terminals, windfarms, etc.), and research (including sound from air guns, sonar, and telemetry). Vessel noise, in particular, is a major contributor to noise in the ocean and is intensively produced in inshore waters. Commercial shipping's contribution to ambient noise in the ocean increased by as much as 12 dB between approximately the 1960s and 2005 (Hildebrand, 2009; McDonald et al., 2008). Frisk (2012) confirmed the trend, and reported that between 1950 and 2007 ocean noise in the 25 to 50 Hz frequency range has increased 3.3 dB per decade, resulting in a cumulative increase of approximately 19 dB over a baseline of 52 dB (decibels re 1 $\mu Pa^2/Hz$). The increase in noise is associated with an increase in commercial shipping, which correlates with global economic growth (Frisk, 2012). Miksis-Olds and Nichols (2015) found low-frequency ocean sound levels have decreased in the South Atlantic and Equatorial Pacific Oceans, similar to a trend of slightly decreasing low-frequency noise levels in the Northeast Pacific. In addition to vessels, other sources of underwater noise include pile-driving activity (Carlson et al., 2007b; Casper et al., 2012b; Casper et al., 2013a; Casper et al., 2013b; Dahl et al., 2015; Debusschere et al., 2014; Feist et al., 1992; Halvorsen et al., 2012b; Popper et al., 2006; Ruggerone et al., 2008; Stadler & Woodbury, 2009), sonar (Carlson et al., 2007b; Mueller-Blenkle et al., 2010; Popper et al., 2006), seismic activity (California Department of Transportation, 2001; Popper & Hastings, 2009a), and offshore construction projects (Foderaro, 2015).

Noise can cause permanent injury in some marine animals (Popper et al., 2005). Physiological responses to noise have shown a variety of results. For example, the giant kelpfish (*Heterostichus rostratus*) exhibited acute stress response when exposed to intermittent recorded boat engine noise (Nichols et al., 2015). In another study, Holles et al. (2013) found that local, low intensity noise from recreational boat engines has the capacity to disrupt settlement in coral reef fish larvae, which may lead to impacts on recruitment to adult populations.

3.6.2.1.4.3 Disease and Parasites

Fishes in poor quality environments have higher incidences of disease, due to increased stress levels and decreased immune system function and are less resilient to fight the disease. Parasites, bacteria, aquaculture conditions, environmental influences, and poor nourishment contribute to fish disease levels (National Oceanic and Atmospheric Administration, 2016b). Disease outbreaks in fishes are influenced by environmental conditions, which typically are more variable in inshore waters compared to the open ocean (Snieszko, 1978). Areas with higher density fish populations, such as marine protected areas and fish farms, are at higher risk for disease compared to areas with lower densities (National Oceanic and Atmospheric Administration, 2016c; Wootton et al., 2012). Additionally, introduced species may expose native species to new diseases and parasites. Sea lice (*Lepeophtheirus* spp. and *Caligus* spp.) are parasites and vectors of viruses commonly associated with fish farming activities in the Study Area that can negatively impact wild fish populations in areas surrounding fish farms (Thorstad et al., 2015; Whelan, 2010).

3.6.2.1.4.4 Invasive Species

Native fish populations are affected by invasive (introduced, non-native) species by predation, competition and hybridization (Moyle & Cech, 2004). Non-native fishes pose threats to native fishes when they are introduced into an environment lacking natural predators and then either compete with native marine fishes for resources or prey upon the native marine fishes (Crain et al., 2009). Marine invasions by other non-fish species also may impact fish populations. Invasive marine algae have been found to alter the health status of native fishes feeding on the algae, which could impact the reproduction success of those populations (Felline et al., 2012).

In the Study Area, a particularly damaging invasive fish species is the predatory Indo-Pacific lionfish (*Pterois volitans* and *P. miles*). This species has spread swiftly across the Western Atlantic, producing a marine predator invasion of unparalleled speed and magnitude (Green et al., 2012). This study also found a 65 percent decline in the biomass of the lionfish's prey fishes with the increase in lionfish abundance within just two years. The increase in lionfish may have long-term impacts for the marine ecosystem (Green et al., 2012).

3.6.2.1.4.5 Climate Change

Global climate change is impacting and will continue to impact marine and estuarine fishes and fisheries (Intergovernmental Panel on Climate Change, 2014; Roessig et al., 2004). Climate change is contributing to a shift in fish distribution from lower to higher latitudes (Brander, 2010; Brander, 2007; Dufour et al., 2010; Popper & Hastings, 2009a; Wilson et al., 2010). Warming waters over the past quarter-century have driven fish populations in the northern hemisphere northward and to deeper depths (Inman, 2005).

Fishes with shifting distributions have faster life cycles and smaller body sizes than non-shifting species (Perry et al., 2005). In addition to affecting species ranges, increasing temperature has been shown to alter the sex-ratio in fish species such as the freshwater zebrafish (*Danio rerio*) that have temperature-dependent sex determination mechanisms (Ospina-Alvarez & Piferrer, 2008). Further temperature rises are likely to have profound impacts on commercial fisheries through continued shifts in distribution and alterations in community interactions (Perry et al., 2005). It appears that diadromous and benthic fish species are most vulnerable to climate change impacts (Hare et al., 2016).

Ocean acidification, the process where increasing atmospheric carbon dioxide concentrations are reducing ocean pH and carbonate ion concentrations, may have serious impacts on fish development and behavior (Raven et al., 2005). Physiological development of fishes can be affected by increases in pH that can increase the size, density, and mass of fish otoliths (e.g., fish ear stones) which would affect sensory functions (Bignami et al., 2013). Ocean acidification may affect fish larvae behavior and could impact fish populations (Munday et al., 2009). A range of behavioral traits critical to survival of newly settled fish larvae are affected by ocean acidification. Settlement-stage larval marine fishes exposed to elevated carbon dioxide were less responsive to threats than controls. This decrease in sensitivity to risk might be directly related to the impaired olfactory ability (Munday et al., 2009).

Beyond direct impacts on fishes from increasing pH ocean acidification can cause changes to the ocean chemistry which leads to increased algal blooms (Anderson et al., 2002). Ocean acidification can also lead to reef impacts such as coral bleaching and can also lead to reduced larval settlement and abundance (Doropoulos et al., 2012). Plankton are important prey items for many fish species and are also impacted by ocean acidification. Ocean acidification may cause a shift in phytoplankton community composition and biochemical composition that can impact the transfer of essential compounds to predators that eat the plankton (Bermudez et al., 2016) and can cause shifts in community composition.

Another climate change effect is ocean deoxygenation. Netburn and Koslow (2015) found that the depth of the lower boundary of the deep scattering layer is most strongly correlated with dissolved oxygen concentration, and irradiance and oxygen concentration are the key variables determining the upper boundary. This study estimated the corresponding annual rate of change of deep scattering layer depths and hypothesized that if past trends continue, the upper boundary is expected to rise at a faster rate than the lower boundary, effectively widening the deep scattering layer under climate changes scenarios. Cao et al. (2014) modeled different sensitivities of ocean temperature, carbonate chemistry, and oxygen, in terms of both the sign and magnitude to the amount of climate change. Model simulations in this study found by the year 2500, every degree increase of climate sensitivity warms the ocean by 0.8 degrees Celsius (°C) and reduces ocean-mean dissolved oxygen concentration by 5.0 percent. Conversely, every degree increase of climate sensitivity buffers CO_2-induced reduction in ocean-mean carbonate ion concentration and pH by 3.4 percent and 0.02 units, respectively. These results have great implications for understanding the response of ocean biota to climate change.

3.6.2.1.4.6 Marine Debris

Marine debris is a widespread global pollution problem and trends suggest that accumulations are increasing with increasing plastic production (Rochman et al., 2013). Debris includes plastics, metals, rubber, textiles, derelict fishing gear, vessels, and other lost or discarded items. Debris such as abandoned nets and lines also pose a threat to fishes. Due to body shape, habitat use, and feeding strategies, some fishes are more susceptible to marine debris entanglement than others (Musick et al., 2000; Ocean Conservancy, 2010). Entanglement in abandoned commercial and recreational fishing gear has caused declines for some marine fishes.

Microplastics in the marine environment are well documented, and interactions with marine biota, including numerous fish species have been described worldwide (Lusher et al., 2016). Plastic waste in the ocean chemically attracts hydrocarbon pollutants such as polychlorinated biphenyl (PCB) and dichlorodiphenyltrichloroethane, which accumulate up to one million times more in plastic than in ocean water (Mato et al., 2001). Fishes can mistakenly consume these wastes, containing elevated levels of toxins, instead of their prey. Rochman et al., (2015) found marine debris in 28 percent of the individual fish examined and in 55 percent of all fish species analyzed. Ribic et al. (2010) concluded that the vast majority of marine debris along the southeast Atlantic coast was either land-based (38 percent), general-source debris (42 percent), or ocean-based (20 percent) recreational and commercial sources (Ribic et al., 2010); no items of military origin were differentiated.

3.6.2.2 Endangered Species Act-Listed Species

In the Study Area, 10 fish species are listed as endangered or threatened under the ESA (Table 3.6-1). Atlantic salmon, Atlantic sturgeon, and Gulf sturgeon are anadromous species that are primarily found in coastal waters, but which spend substantial portions of their lifecycle in estuarine and riverine waters. The shortnose sturgeon inhabits its natal river and estuary, and very rarely has been observed in coastal waters. Largetooth sawfish and smalltooth sawfish are predominately estuarine and coastal waters, but can also occur in freshwater and deeper ocean waters. Scalloped hammerhead is generally considered a marine fish but has early life stages which are estuarine. Nassau groupers, are marine fishes that inhabit deep coral reefs or rocky substrate in Florida and the Caribbean. Giant manta rays and oceanic whitetip sharks are primarily pelagic and oceanic in distribution and can occur throughout the Study Area.

In addition to the aforementioned listed species, there are also a number of other species that are under consideration for listing. These species are broken into two categories: candidates for listing and proposed for listing. Candidate species are any species that are undergoing a status review that have been announced in a *Federal Register* notice. Proposed species are those candidate species that were found to warrant listing as either threatened or endangered and were officially proposed as such in a *Federal Register* notice after the completion of a status review and consideration of other protective conservation measures.

There are four candidate species found within the Study Area, including the alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), cusk (*Brosme brosme*), and dwarf seahorse

(*Hippocampus zosterae*) (Table 3.6-1). Currently, there are no fish species proposed for listing that occur in the Study Area. NMFS also manages a proactive conservation program that allows for species with concerns regarding status and threats, but for which insufficient information is available to indicate a need for listing under the ESA. These species are listed as "species of concern." Within the Study Area, there are 13 fish species listed as such: Alabama shad (*Alosa alabamae*), Atlantic bluefin tuna (*Thunnus thynnus*), Atlantic halibut (*Hippoglossus hippoglossus*), Atlantic wolffish (*Anarhichas lupus*), dusky shark (*Carcharhinus obscurus*), key silverside (*Menidia conchorum*), mangrove rivulus (*Kleptolebias marmoratus*), opossum pipefish (*Microphis brachyurus lineatus*), rainbow smelt (*Osmerus mordax*), sand tiger shark (*Carcharias taurus*), speckled hind (*Epinephelus drummondhayi*), striped croaker (*Corvula sanctaeluciae*), and Warsaw grouper (*Hyporthodus nigritus*) (Table 3.6-1). As the species of concern are not considered for listing at this time, they will not be discussed separately in this document.

Table 3.6-1: Regulatory Status and Occurrence of Endangered Species Act-Listed Fishes in the Study Area

Regulatory Status			*Occurrence in the Study Area*		
Common Name	***Scientific Name***	***Endangered Species Act Status***	***Open Ocean***	***Large Marine Ecosystems***	***Inshore Waters***
Atlantic Salmon (Gulf of Maine Distinct Population Segment)	*Salmo salar*	Endangered	N/A	West Greenland Shelf, Scotian Shelf, Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf	Kennebec River Estuary, ME
Atlantic Sturgeon (New York Bight, Chesapeake Bay, Carolina, & South Atlantic Distinct Population Segments)	*Acipenser oxyrinchus oxyrinchus*	Endangered	N/A	Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf	Kennebec River Estuary, ME; Narragansett Bay and Rhode Island Sound, RI; Thames River Estuary, CT; Sandy Hook Bay, NJ; lower Chesapeake Bay, VA; Beaufort Inlet Channel, and Cape Fear River, NC; Kings Bay, GA; St. Johns River, FL
Largetooth Sawfish	*Pristis pristis*	Endangered	Extirpated	Extirpated	Extirpated
Shortnose Sturgeon	*Acipenser brevirostrum*	Endangered	N/A	Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf	Kennebec River Estuary, ME; Narragansett Bay and Rhode Island Sound, RI; Thames River Estuary, CT; Sandy Hook Bay, NJ; Cape Fear River, NC; Kings Bay, GA; St. Johns River, FL
Smalltooth Sawfish	*Pristis pectinata*	Endangered	N/A	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea	St. Andrew Bay, FL; Pascagoula River Estuary, MS; Sabine Lake and Corpus Christi Bay, TX
Atlantic Sturgeon (Gulf of Maine Distinct Population Segment)	*Acipenser oxyrinchus oxyrinchus*	Threatened	N/A	Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf	Kennebec River Estuary, ME; Narragansett Bay and Rhode Island Sound, RI; Thames River Estuary, CT; Sandy Hook Bay, NJ; lower Chesapeake Bay, VA

Table 3.6-1: Regulatory Status and Occurrence of Endangered Species Act-Listed Fishes in the Study Area (continued)

Regulatory Status			*Occurrence in the Study Area*		
Common Name	***Scientific Name***	***Endangered Species Act Status***	***Open Ocean***	***Large Marine Ecosystems***	***Inshore Waters***
Giant Manta Ray	*Manta birostris*	Threatened	North Central Atlantic Gyre, Gulf Stream	Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea	N/A
Gulf Sturgeon	*Acipenser oxyrinchus desotoi*	Threatened	N/A	Gulf of Mexico	St. Andrew Bay, FL; Pascagoula River Estuary, MS
Nassau Grouper	*Epinephelus striatus*	Threatened	N/A	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea	N/A
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Threatened	North Central Atlantic Gyre, Gulf Stream	Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea	N/A
Scalloped Hammerhead (Central and Southwest Atlantic Distinct Population Segment)	*Sphyrna lewini*	Threatened	N/A	Caribbean Sea	N/A
Alewife	*Alosa pseudoharengus*	Candidate	Gulf Stream	Scotian Shelf, Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf	Kennebec River Estuary, ME; Narragansett Bay and Rhode Island Sound, RI; Thames River Estuary, CT; Sandy Hook Bay, NJ; lower Chesapeake Bay, VA; Beaufort Inlet Channel and Cape Fear River, NC; Kings Bay, GA; St. Johns River, FL

Table 3.6-1: Regulatory Status and Occurrence of Endangered Species Act-Listed Fishes in the Study Area (continued)

Regulatory Status			*Occurrence in the Study Area*		
Common Name	***Scientific Name***	***Endangered Species Act Status***	***Open Ocean***	***Large Marine Ecosystems***	***Inshore Waters***
Blueback Herring	*Alosa aestivalis*	Candidate	Gulf Stream	Scotian Shelf, Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf	N/A
Cusk	*Brosme brosme*	Candidate	Labrador Current, North Central Atlantic Gyre, Gulf Stream	Scotian Shelf, Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf	N/A
Dwarf Seahorse	*Hippocampus zosterae*	Candidate	N/A	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea	St. Johns River and St. Andrew Bay, FL; Pascagoula River Estuary, MS; Sabine Lake and Corpus Christi Bay, TX
Alabama Shad	*Alosa alabamae*	Species of Concern	N/A	Gulf of Mexico	St. Andrew Bay, FL; Pascagoula River Estuary, MS
Atlantic Bluefin Tuna	*Thunnus thynnus*	Species of Concern	North Central Atlantic Gyre, Gulf Stream	Scotian Shelf, Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea	N/A

Table 3.6-1: Regulatory Status and Occurrence of Endangered Species Act-Listed Fishes in the Study Area (continued)

Regulatory Status			*Occurrence in the Study Area*		
Common Name	***Scientific Name***	***Endangered Species Act Status***	***Open Ocean***	***Large Marine Ecosystems***	***Inshore Waters***
Atlantic Halibut	*Hippoglossus hippoglossus*	Species of Concern	Labrador Current; North Central Atlantic Gyre; Gulf Stream	West Greenland Shelf, Scotian Shelf, Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf	N/A
Atlantic Wolffish	*Anarhichas lupus*	Species of Concern	Labrador Current, North Central Atlantic Gyre, Gulf Stream	West Greenland Shelf, Scotian Shelf, Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf	N/A
Dusky Shark	*Carcharhinus obscurus*	Species of Concern	Gulf Stream	Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea	Juveniles only; Sandy Hook Bay, NJ; lower Chesapeake Bay, VA
Key Silverside	*Menidia conchorum*	Species of Concern	N/A	Gulf of Mexico	N/A
Mangrove Rivulus	*Kleptolebias marmoratus*	Species of Concern	N/A	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean	Mangroves throughout Study Area
Opossum Pipefish	*Microphis brachyurus lineatus*	Species of Concern	Gulf Stream	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea	St. Andrew Bay, FL; Pascagoula River Estuary, MS; Sabine Lake and Corpus Christi Bay, TX
Rainbow Smelt	*Osmerus mordax*	Species of Concern	N/A	Scotian Shelf, Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf	Kennebec River Estuary, ME; Narragansett Bay and Rhode Island Sound, RI; Thames River Estuary, CT; Sandy Hook Bay, NJ

Table 3.6-1: Regulatory Status and Occurrence of Endangered Species Act-Listed Fishes in the Study Area (continued)

Regulatory Status			*Occurrence in the Study Area*		
Common Name	***Scientific Name***	***Endangered Species Act Status***	***Open Ocean***	***Large Marine Ecosystems***	***Inshore Waters***
Sand Tiger Shark	*Carcharias taurus*	Species of Concern	Gulf Stream	Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf, Gulf of Mexico, Caribbean Sea	Narragansett Bay and Rhode Island Sound, RI; Thames River Estuary, CT; Sandy Hook Bay; lower Chesapeake Bay, VA; Beaufort Inlet Channel and Cape Fear River, NC; Kings Bay, GA; St. Johns River and St. Andrew Bay, FL; Pascagoula River Estuary, MS; Sabine Lake and Corpus Christi Bay, TX
Speckled Hind	*Epinephelus drummondhayi*	Species of Concern	N/A	Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea	Gulf Stream
Striped Croaker	*Corvula sanctaeluciae*	Species of Concern	N/A	Southeast U.S. Continental Shelf, Caribbean Sea	N/A
Warsaw Grouper	*Hyporthodus nigritus*	Species of Concern	Gulf Stream	Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, Caribbean Sea	N/A

[1]Candidate and species of concern status does not carry any procedural or substantive protections under the ESA, but is provided for informational purposes.
[2]N/A = not applicable

3.6.2.2.1 Atlantic Salmon (*Salmo salar*)

3.6.2.2.1.1 Status and Management

The Gulf of Maine Distinct Population Segment of Atlantic salmon was listed as federally endangered in 2000 (65 *Federal Register* 69459). During 2009, the Gulf of Maine Distinct Population Segment was expanded to include Maine's Penobscot, Kennebec, and Androscoggin rivers, which support remnant wild populations (74 *Federal Register* 29300). The Atlantic salmon is co-managed by NMFS and USFWS because its lifecycle spans marine, estuarine, and freshwater habitats. Although Atlantic salmon may occur elsewhere (e.g., hatchery programs and aquaculture), only the Gulf of Maine Distinct Population Segment is protected under the ESA.

In June 2009, critical habitat was designated in 45 areas within Maine for the Gulf of Maine Distinct Population Segment of Atlantic salmon (74 *Federal Register* 117; Figure 3.6-1). Critical habitat was designated to include all perennial rivers, streams, and estuaries and lakes connected to the marine environment within the range of the Gulf of Maine Distinct Population Segment of Atlantic salmon, except for those particular areas within the range which are specifically excluded. Within the distinct population segment, the physical and biological features for Atlantic salmon include sites for spawning and incubation, sites for juvenile rearing, and sites for migration. The physical and biological features of habitat are those features that allow Atlantic salmon to successfully use sites for spawning and rearing and sites for migration. These features include:

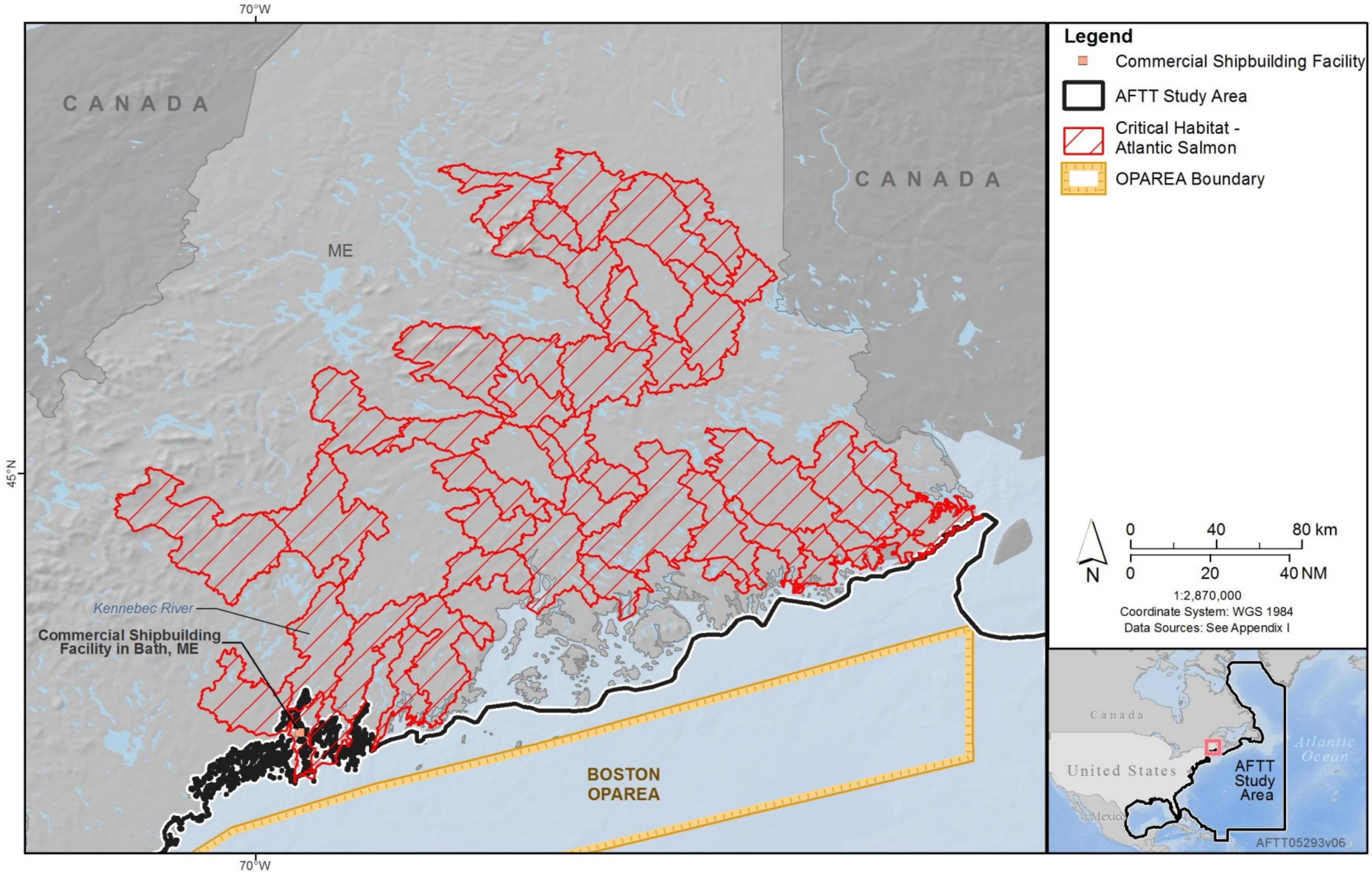
1. Substrate of suitable size and quality; rivers and streams of adequate flow, depth, water temperature and water quality;
2. Rivers, streams, lakes and ponds with sufficient space and diverse, abundant food resources to support growth and survival;
3. Waterways that allow for free migration of both adult and juvenile Atlantic salmon; and
4. Diverse habitat and native fish communities in which salmon interact with while feeding, migrating, spawning, and resting.

In 2015, NMFS focused efforts to protect species that are most at risk of extinction in the near future. The Atlantic salmon was selected as one of the eight species because of their critically low abundance and declining population trends. Key actions include reconnecting the Gulf of Maine with headwater streams, increasing the number of juveniles successfully emigrating into the marine environment, reducing mortality in international fishery in West Greenland waters, and increasing the understanding and ability to improve survival in the marine environment (National Marine Fisheries Service, 2016b).

3.6.2.2.1.2 Habitat and Geographic Range

Atlantic salmon is an anadromous and iteroparous (does not die after spawning like other salmon) species. After hatching, juveniles rear in their natal rivers and estuaries. After juveniles complete the smolting process (e.g., physiologically transforming into marine form called a smolt), they enter the estuarine portion of the Study Area in the Gulf of Maine, primarily at night, during the late spring when water temperatures reach 10° C (50° F) (Sheehan et al., 2012) and school in coastal waters primarily in the upper 3 m (10 ft.), although may occur in deeper waters (Hedger et al., 2009). Adults migrate back to their natal river to spawn.

Labrador Current Large Marine Ecosystem. By mid-summer, smolts migrate to the Gulf of Maine along the Scotian Shelf Large Marine Ecosystem, reaching the Newfoundland-Labrador Shelf Large Marine Ecosystem and the Grand Banks (Fay et al., 2006), as indicated by tag recoveries (McCormick et al., 1998). For much of their first summer, sub-adults inhabit the coastal waters off Canada, the Southern Grand Banks (Newfoundland-Labrador Shelf Large Marine Ecosystem), the Labrador Sea, and the northern Gulf of St. Lawrence (Reddin & Short, 1991). Decreasing nearshore water temperatures in autumn trigger offshore (greater than 3 NM from shoreline) movements (Dutil & Coutu, 1988). Sub-adults overwinter in the Labrador Sea south of Greenland. Small percentages return to Gulf of Maine coastal rivers after their first winter at sea (Fay et al., 2006).



Note: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area

Figure 3.6-1: Critical Habitat Areas for Atlantic Salmon in and Adjacent to the Study Area

West Greenland Shelf Large Marine Ecosystem. Atlantic salmon migrate great distances in the open ocean to reach feeding areas in the West Greenland Shelf Large Marine Ecosystem and in the Davis Strait between Labrador and Greenland, nearly 2,500 miles (mi.) from their natal rivers (Fay et al., 2006; Reddin & Short, 1991). North American and European stocks co-occur in these areas while feeding (Fay et al., 2006). They spend up to two years feeding before returning to Gulf of Maine coastal rivers to spawn (Reddin & Short, 1991).

Northeast U.S. Continental Shelf Large Marine Ecosystem. The historic range of Atlantic salmon in the northwestern Atlantic Ocean includes coastal drainages from northern Quebec, Canada, to Connecticut. Smolts migrate into marine habitats during approximately two weeks each spring, usually during May (McCormick et al., 1998). Spawning adults migrate into estuaries and natal rivers throughout the spring and summer with the peak occurring in June (Fay et al., 2006).

3.6.2.2.1.3 Population Trends

By the end of the 19th century, Atlantic salmon had been extirpated from the Androscoggin, Merrimack, and Connecticut rivers. The Gulf of Maine Distinct Population Segment represents the last wild population. Populations have been extirpated or decreased from land use practices and development that eliminated spawning and rearing habitat and reduced water quality. The population remains in decline. With added conservation efforts, adult returns remain extremely low. The National Oceanic and Atmospheric Administration reported an estimated extinction risk of 19 to 75 percent within the next 100 years for the Gulf of Maine Distinct Population Segment, which included the on-going hatchery supplementation.

Adult return rates have continued to decline since the 1980s which indicates low marine survival (Chaput, 2012). Population estimates have rarely exceeded 5,000 in any given year since 1967, whereas historical abundances (excluding the Penobscot River) likely exceeded 100,000 (Fay et al., 2006). Numerous conservation and restoration practices have slowed the population decline, but have not increased recovery. Similar to salmon populations on the West Coast of the U.S., changes in ocean conditions affect recovery rates.

3.6.2.2.1.4 Predator and Prey Interactions

Upon ocean entry, smolts feed on fish larvae (Haugland et al., 2006), amphipods, euphausiids, and small fish (Fraser, 1987; Hislop & Youngson, 1984; Hislop & Shelton, 1993; Jutila & Toivonen, 1985). As they grow, small fishes become an increasingly dominant component of their diet. Striped bass, cod, haddock, fish-eating birds, and marine mammals feed on smolts and subadults in the marine environment. Adults prey on capelin, Atlantic herring, and sand lance (Hansen & Windsor, 2006). Adults are vulnerable to predation by seals and cormorants (Fay et al., 2006).

3.6.2.2.1.5 Species-Specific Threats

Incremental increases in marine survival (survival from emigrating smolts to adult returns) have a much greater impact on the population than comparable increases in freshwater survival (Legault, 2005), however, the factors contributing to low marine survival are not well understood. A review of existing studies indicates that mortality during the early marine migration varies between 8 and 71 percent, with predation being the most common cause of low survival in rivers and estuaries (Thorstad et al., 2015). In recent decades, individuals have migrated to sea at a younger age; these smaller smolts are subject to increased mortality (Russell et al., 2012). Sea lice infestation of farmed fish is a major cause of mortality of adults (Gargan et al., 2012). Parasitic crustaceans have also been noted to cause mortality and are common in areas with large aquaculture populations (Krkosek et al., 2013).

The primary threats impacting the juvenile life stages include restricted fish passage (Baum, 1997), degraded water quality and aluminum toxicity (Kroglund et al., 2007), commercial aquaculture (Hansen & Windsor, 2006), and lack of spawning habitat (Fay et al., 2006). Increases in juvenile survival could enhance the probability of recovery, but only if marine survival is also increased. Current research shows that the catch and release recreational fishery does not negatively impacted the adult population during the spawning migration (Lennox et al., 2016).

3.6.2.2.2 Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)

3.6.2.2.2.1 Status and Management

Atlantic sturgeon is co-managed by Atlantic States Marine Fisheries Commission and NMFS. Sharp declines in the abundance of Atlantic sturgeon resulting from historic overfishing, pollution, habitat loss, and habitat degradation led the Atlantic States Marine Fisheries Commission to issue a coast-wide moratorium on the commercial harvest in state waters in 1998 (63 *Federal Register* 9967). This was followed closely by a similar moratorium in federal waters issued by NMFS in early 1999 (64 *Federal Register* 9449). When the population continued to decline, National Oceanic and Atmospheric Administration listed the species as endangered or threatened throughout its range in 2012 (77 *Federal Register* 5880; 77 *Federal Register* 5914). The Chesapeake, New York Bight, Carolina, and South Atlantic Distinct Population Segments are listed as endangered and the Gulf of Maine Distinct Population Segment as threatened.

In August 2017, NMFS designated critical habitat for each of the five Atlantic sturgeon distinct population segments: Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic (82 *Federal Register* 39160; Figure 3.6-2 and Figure 3.6-3). All critical habitat designations are riverine waters between Maine and Georgia related to spawning or potential spawning habitat.

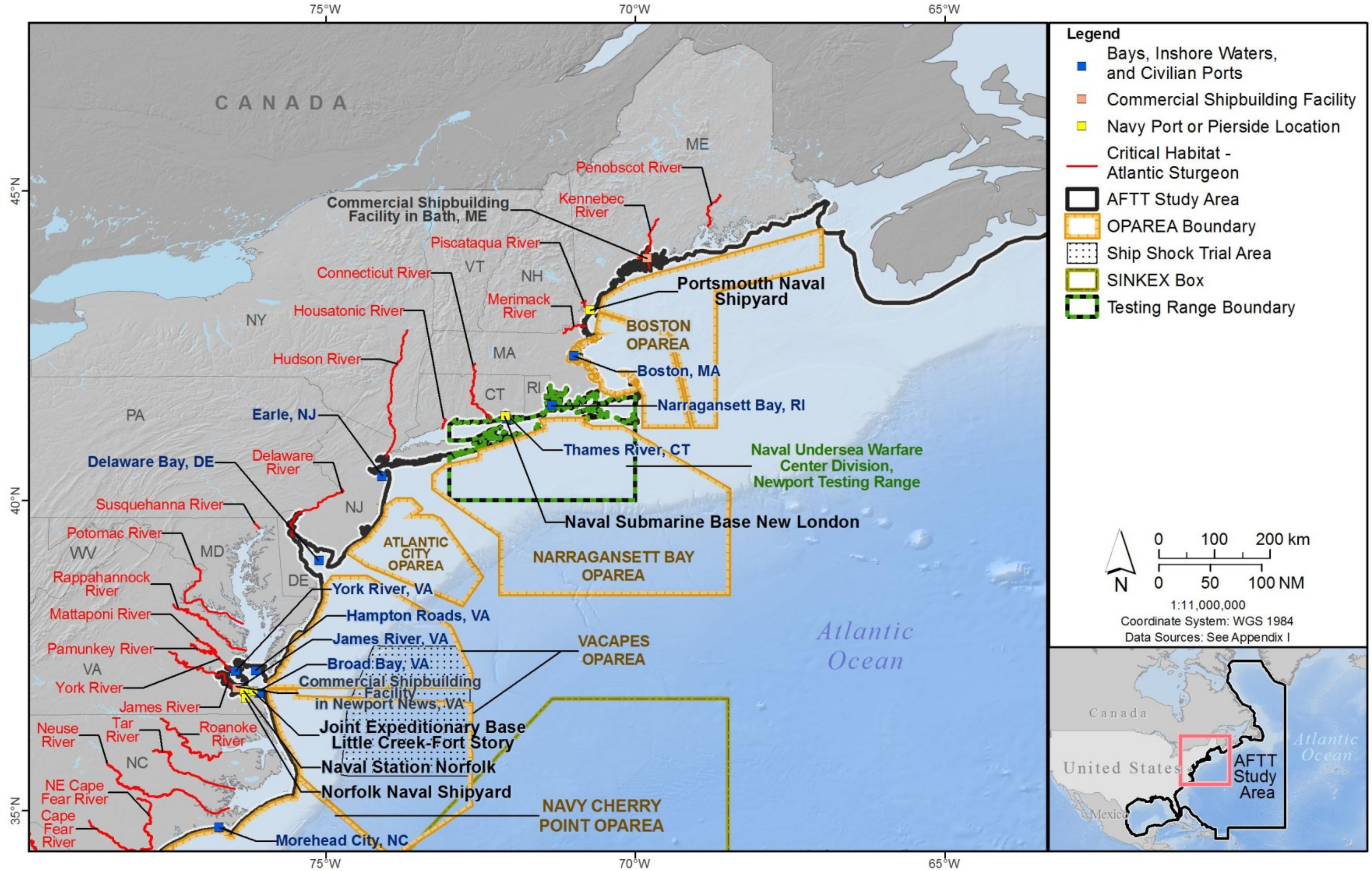
Critical habitat for the Gulf of Maine Distinct Population Segments of Atlantic sturgeon has been designated in the Penobscot, Kennebec, Androscoggin, and Piscataqua rivers in Maine, Piscataqua River in New Hampshire, and Merrimack River in Massachusetts (82 *Federal Register* 39160).

Critical habitat for the New York Bight Distinct Population Segments of Atlantic sturgeon has been designated in the Connecticut River in Massachusetts, Connecticut and Housatonic rivers in Connecticut, the Hudson River in New York, the Hudson and Delaware rivers in New Jersey, and the Delaware River in Pennsylvania and Delaware (82 *Federal Register* 39160).

Critical habitat for the Chesapeake Bay Distinct Population Segments of Atlantic sturgeon has been designated in the Nanticoke and Potomac rivers, as well as the Marshyhope Creek in Maryland, and the Rappahannock, York, Mattaponi, Pamunkey, and James rivers in Virginia (82 *Federal Register* 39160).

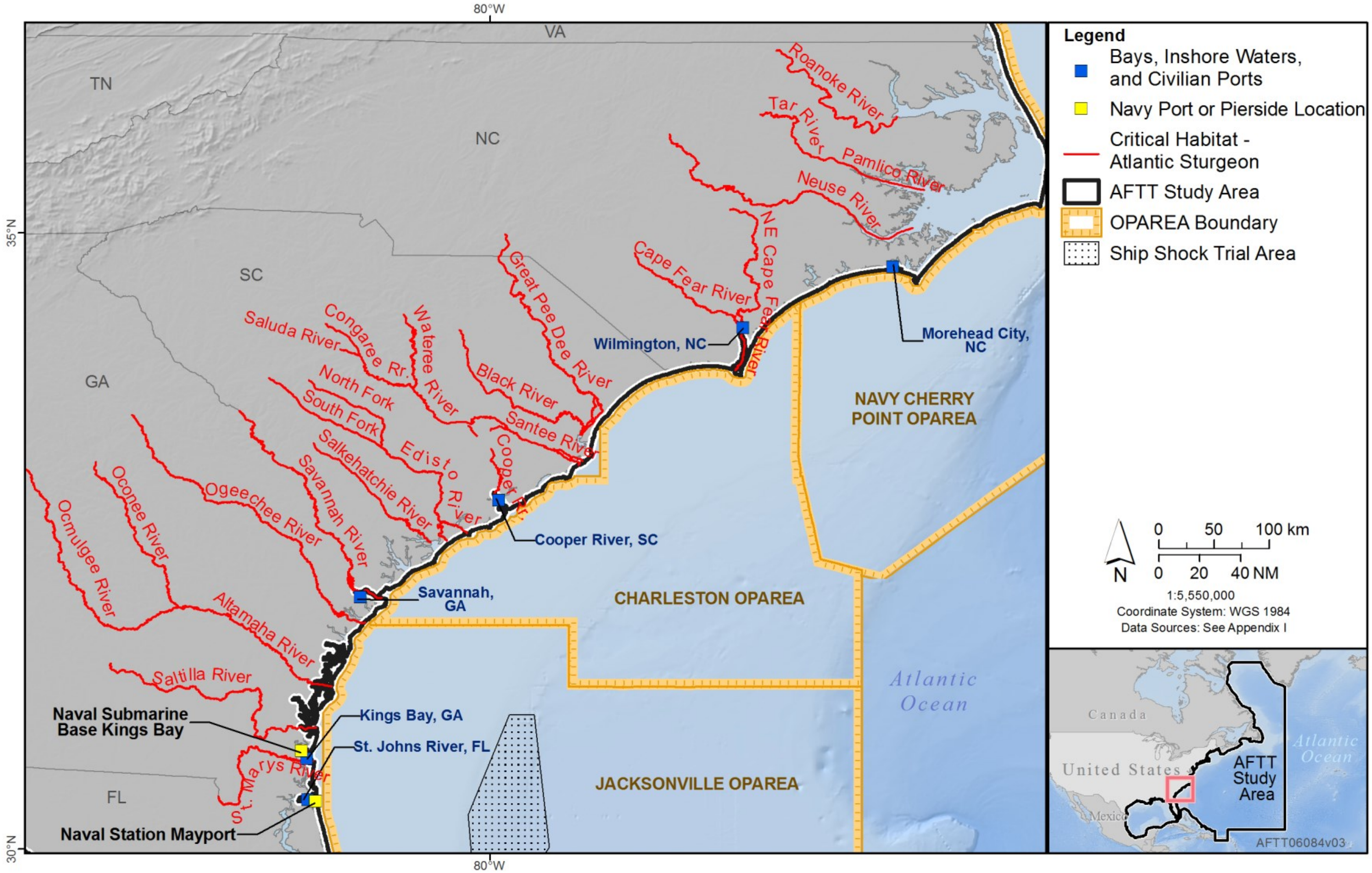
Critical habitat for the Carolina Distinct Population Segment of Atlantic sturgeon has been designated in the Roanoke, Tar-Pamlico, Neuse, Northeast Cape Fear, Cape Fear, and Pee Dee rivers in North Carolina; and Pee Dee, Black, Santee, and Cooper rivers in South Carolina (82 *Federal Register* 39160).

Critical habitat for the South Atlantic Distinct Population Segment has been designated in the Edisto, Combahee, and Savannah rivers in South Carolina, the Ogeechee, Altamaha, Satilla, and St. Marys rivers in Georgia, and the St. Marys River in Florida (82 *Federal Register* 39160).



Note: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; VACAPES: Virginia Capes

Figure 3.6-2: Critical Habitat for Atlantic Sturgeon in and Adjacent to the Northern Portion of the Study Area



Note: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

Figure 3.6-3: Critical Habitat for Atlantic Sturgeon in and Adjacent to the Southern Portion of the Study Area

The physical features essential for the conservation of Atlantic sturgeon belonging to the Gulf of Maine, New York Bight, and Chesapeake Bay Distinct Population Segments are those habitat components that support successful reproduction and recruitment. These include:

1. Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0 to 0.5 parts per thousand range) for settlement of fertilized eggs, refuge, growth, and development of early life stages;
2. Aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 parts per thousand and soft substrate (e.g., sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development;
3. Water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support:

   a. Unimpeded movement of adults to and from spawning sites;

   b. Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary;

   c. Staging, resting, or holding of subadults or spawning condition adults. Water depths in main river channels must also be deep enough (e.g., at least 1.2 meters) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river;

   d. Water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support:

      i. Spawning;

      ii. Annual and interannual adult, subadult, larval, and juvenile survival; and

      iii. Larval, juvenile, and subadult growth, development, and recruitment (e.g., 13 — 26 °C for spawning habitat and no more than 30 °C for juvenile rearing habitat, and 6 milligrams per liter (mg/L) or greater dissolved oxygen for juvenile rearing habitat).

The physical features essential for the conservation of Atlantic sturgeon belonging to the Carolina and South Atlantic Distinct Population Segments are those habitat components that support successful reproduction and recruitment. These include:

1. Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0 to 0.5 parts per thousand range) for settlement of fertilized eggs and refuge, growth, and development of early life stages;
2. Aquatic habitat inclusive of waters with a gradual downstream gradient of 0.5 up to as high as 30 parts per thousand and soft substrate (e.g., sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development;
3. Water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support:

   a. Unimpeded movement of adults to and from spawning sites;

   b. Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and

c. Staging, resting, or holding of subadults or spawning condition adults. Water depths in main river channels must also be deep enough (at least 1.2 meters) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river;

4. Water quality conditions, especially in the bottom meter of the water column, with temperature and oxygen values that support:

   a. Spawning;

   b. Annual and inter-annual adult, subadult, larval, and juvenile survival; and

   c. Larval, juvenile, and subadult growth, development, and recruitment. Appropriate temperature and oxygen values will vary interdependently, and depending on salinity in a particular habitat. For example, 6.0 mg/L dissolved oxygen or greater likely supports juvenile rearing habitat, whereas dissolved oxygen less than 5.0 mg/L for longer than 30 days is less likely to support rearing when water temperature is greater than 25 °C. In temperatures greater than 26 °C, dissolved oxygen greater than 4.3 mg/L is needed to protect survival and growth. Temperatures of 13 to 26 °C likely support spawning habitat.

3.6.2.2.2.2 Habitat and Geographic Range

Subadult and adult Atlantic sturgeon inhabits the Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, and Southeast U.S. Continental Shelf Large Marine Ecosystems, likely year-round. Juveniles, sub-adults, and adults also inhabit many of the estuarine and riverine systems that are included in the Study Area (e.g., Kennebec River in Maine, Chesapeake Bay, James River and York River in Virginia, Cooper River in South Carolina, St. Johns River in Florida, and St. Marys River and Kings Bay in Georgia). Larvae are not known to inhabit the Study Area.

Atlantic sturgeon are fairly well studied during their juvenile and spawning life phases in riverine environments, but their sub-adult and adult estuarine and marine phases are less understood. Females spawn highly adhesive eggs on cobble substrate located on river bottoms, which are fertilized by males. Breece et al. (2013) found that spawning habitat was influenced by salinity and substrate composition. Larvae hatch out in four to seven days, and newly hatched young are active swimmers, frequently leaving the bottom and swimming throughout the water column. After 9 to 10 days, the yolk sac is absorbed and the larvae begin to show more strictly benthic behavior. Juveniles remain riverine and estuarine residents for two to six years before migrating to the Atlantic Ocean. After reaching 76 to 92 centimeters (cm) in length (30 to 36 inches [in.]), subadults move from natal estuaries into the marine environment, and may undertake long range migrations (Atlantic Sturgeon Status Review Team, 2007). Sub-adults disperse widely both north and south along the Atlantic coast and beyond the continental shelf (Bain, 1997). Sub-adults and adults were found to be strongly associated within a narrow range of depths 10 to 50 m over gravel and sand and, to lesser extent, silt and clay (Stein et al., 2004) and in temperatures around 20° C (Breece et al., 2016). Age of sexual maturity varies from 5 to 34 years depending on latitude, averaging 15 years (Atlantic Sturgeon Status Review Team, 2007). Sturgeon in the southern parts of the range tend to mature faster, but experience shorter lifespans than sturgeon in the northern portions of the range. Despite extensive mixing in coastal waters, adults return to their natal river to spawn as indicated from tagging records. During non-spawning years, adults remain in marine waters either year-round or seasonally venture into either natal or non-natal estuarine environments (Bain, 1997; Hager et al., 2016). As part of a Navy-funded research effort, Hager et al. (2016) found that sturgeon implanted with acoustic transmitters in the York River system in Virginia spent the summer and fall seasons of non-spawning years in either the mainstem of the Chesapeake Bay, the Delaware Bay and the Delaware River, or along the coast of New York and in the Hudson River.

Spawning was originally thought to occur only in the spring along the Atlantic coast; however, recent research indicates that spawning primarily occurs in the fall in the South Atlantic rather than spring (Balazik, 2012; Balazik & Musick, 2015; Hager, 2015; Kahn et al., 2014; Smith et al., 2015). Males and females return to the ocean shortly after spawning. The highly adhesive eggs are deposited on cobble substrate. Juveniles (e.g., larvae life stage) hatch out in 4 to 7 days, assume a demersal existence, and begin to move downstream into their natal estuary, where they remain for a period of time ranging from months to years (Atlantic Sturgeon Status Review Team, 2007). Breece et al. (2013) found that spawning habitats in the Delaware River were influenced by salinity levels and substrate composition, which have been heavily impacted by dredging activities and climate change.

Newfoundland-Labrador Shelf, Scotia Shelf, Northeast U.S. Continental Shelf, and Southeast U.S. Continental Shelf Large Marine Ecosystem. Sub-adult and adult Atlantic sturgeon inhabits the Newfoundland-Labrador Shelf, Scotia Shelf, Northeast U.S. Continental Shelf, and Southeast U.S. Continental Shelf Large Marine Ecosystem year-round. Atlantic sturgeon can range as far north as the coast of Labrador, and as far south as the St. Johns River in Florida.

3.6.2.2.2.3 Population Trends

Atlantic sturgeon is a long-lived (average life span of 60 years), late maturing, estuarine dependent, iteroparous, and anadromous species. Twelve genetically distinct population segments along the U.S. Atlantic coast have been differentiated (Stein et al., 2004). The Hudson River population seemed somewhat large in 1995 with 9,500 juveniles recorded (National Marine Fisheries Service, 2009e). The mean annual spawning stock size has been estimated at 870 adults, although about half may be of hatchery origin (National Marine Fisheries Service, 2007). The Delaware River population has only a few individuals remaining. St. Johns River, Florida spawning population appears to be extinct (Fox et al., 2016; National Marine Fisheries Service, 2007; Waldman & Wirgin, 1998). The species has been historically overfished throughout its range with landings peaking around the turn of the 20th century followed by drastic declines thereafter (Smith & Clugston, 1997).

Historically, Atlantic sturgeon were recorded in 38 rivers from St. Croix, Maine to the Saint Johns River, Florida. As of 2007, they were only known to still occupy 35 rivers (Atlantic Sturgeon Status Review Team, 2007). However, spawning populations have been discovered in at least five new rivers since this estimate and preliminary research indicates there are likely spawning populations in several more rivers that have yet to be fully investigated. In the early 1600s, Atlantic sturgeon had been considered an important fishery. In the mid-1800s, incidental catch of Atlantic sturgeon in the shad and river herring seine fisheries indicated that the species was very abundant (Armstrong & Hightower, 2002). By 1870, females were collected for their eggs, which were sold as caviar. By 1890, over 3,350 metric tons were landed from rivers along the Atlantic coast (Smith & Clugston, 1997). Despite a moratorium on commercial fishing for this species since 1998, there has been no indication of recovery. The lack of recovery is attributed to coastal development, pollution, poor water quality, and habitat degradation and loss.

3.6.2.2.2.4 Predator and Prey Interactions

Atlantic sturgeon prey upon benthic invertebrates such as isopods, crustaceans, worms, and molluscs (National Marine Fisheries Service, 2010c). It has also been documented to feed on fish (Bain, 1997). Evidence of predation on sturgeon is scant, but it is speculated that juveniles may be eaten by the

American alligator (*Alligator mississippiensis*), alligator gar (*Atractosteus spatula*), striped bass (Dadswell, 2006), and sharks.

3.6.2.2.2.5 Species-Specific Threats

Overfishing of females for caviar prior to the 1900s resulted in large population declines. Current threats include: bycatch in fisheries targeting other species; habitat degradation from dredging, dams, and water withdrawals; passage impediments including locks and dams; and ship strikes (Atlantic Sturgeon Status Review Team, 2007; Balazik et al., 2012; Brown & Murphy, 2010; Foderaro, 2015). The copepod (*Dichelesthium oblongum*) parasitizes 93 percent of the Atlantic sturgeon sampled in the New York Bight. High parasite load, stress, and reduced immune suppression has been associated with Atlantic sturgeon inhabiting areas of poor water quality (e.g., sewage contamination) (Fast et al., 2009).

3.6.2.2.3 Largetooth Sawfish (*Pristis pristis*)

3.6.2.2.3.1 Status and Management

In July 2011, NMFS listed the largetooth sawfish, a type of elasmobranch (shark), as endangered throughout its U.S. range (76 *Federal Register* 40822). Based on the fact that the last confirmed record of this species in U.S. waters was from Port Aransas, Texas in 1961, the largetooth sawfish is believed to be extirpated from U.S. waters. No critical habitat is designated for this species (76 *Federal Register* 40822).

3.6.2.2.3.2 Habitat and Geographic Range

Gulf of Mexico Large Marine Ecosystem. The largetooth sawfish has historically been found in shallow, subtropical-tropical, estuarine and marine waters in the southwestern portion of the Gulf of Mexico Large Marine Ecosystem, and was also known to occur in the rivers of Central America or lake systems outside the Study Area (WildEarth Guardians, 2009). Although this species is believed to be extirpated from the Study Area, it historically moved between freshwater and marine habitats, and likely had some type of dispersal between these systems (Kyne & Feutry, 2013).

The largetooth sawfish typically remains close to the bottom of sand or muddy sand, generally in depths less than 35 ft. (11 m) (Kyne & Feutry, 2013). The largetooth sawfish can tolerate a range of salinities, moving freely between salinity gradients (76 *Federal Register* 40822), and is reported in brackish water near river mouths, large embayments, and partially enclosed systems. Largetooth sawfish may occupy deep holes or be found over mud and sand (76 *Federal Register* 40822). Red mangroves and shallow habitats of varying salinity are important nursery habitats for the largetooth sawfish; these shallow habitats support an abundance of prey (WildEarth Guardians, 2009). The complexity of such habitats also provides juveniles with refuges from larger shark species (76 *Federal Register* 40822).

3.6.2.2.3.3 Population Trends

The presence of this species in U.S. waters is under review because it has not been documented in the United States in several decades (76 *Federal Register* 40822).

3.6.2.2.3.4 Predator and Prey Interactions

The largetooth sawfish uses its saw while foraging, either by stirring up the substrate to expose crustaceans or by stunning and slashing schooling fish (76 *Federal Register* 40822). Largetooth sawfish have been documented in the stomachs of American crocodile, narrowtooth sharks, bull sharks, and tiger sharks also prey on various species of sawfishes (Florida Museum of Natural History, 2017a).

3.6.2.2.3.5 Species-Specific Threats

Factors contributing to the decline of the largetooth sawfish include habitat degradation, commercial harvest, gear entanglements, fisheries bycatch, low productivity, and the market for rostral saws (WildEarth Guardians, 2009).

3.6.2.2.4 Shortnose Sturgeon (*Acipenser brevirostrum*)

3.6.2.2.4.1 Status and Management

In 1967, the U.S. Department of Interior listed the shortnose sturgeon as endangered throughout its range (32 *Federal Register* 4001). The species remained listed following enactment of the ESA in 1973 (Wippelhauser & Squiers, 2015). NMFS has recognized 19 Distinct Population Segments. These include New Brunswick, Canada (1); Maine (2); Massachusetts (1); Connecticut (1); New York (1); New Jersey/Delaware (1); Maryland/Virginia (1); North Carolina (1); South Carolina (4); Georgia (4); and Florida (2) (National Marine Fisheries Service, 1998). In September 2014, a petition was created to list the population within the St. John River in New Brunswick, Canada as a distinct population segment under the ESA. Critical habitat for this species remains under development.

3.6.2.2.4.2 Habitat and Geographic Range

The geographic range of shortnose sturgeon runs along eastern North America from the Saint John River, New Brunswick, Canada to the St. Johns River, Florida (Kynard, 1997; National Marine Fisheries Service, 1998). However, the distribution of shortnose sturgeon across this range is disjunct with a separation between the northern populations and the southern populations of approximately 400 km occurring in Virginia near the geographic center of their coast-wide distribution (Kynard, 1997; Shortnose Sturgeon Status Review Team, 2010). After hatching in rivers, larvae orient into the current and away from light, generally staying near the bottom and seeking cover. Within two weeks, the larvae emerge from cover and swim in the water column, moving downstream from the spawning site. Within two months, juvenile behavior mimics adults, with active swimming (Deslauriers & Kieffer, 2012) and foraging at night along the bottom (Richmond & Kynard, 1995). The species primarily occurs in rivers and estuaries of the Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems, occasionally moving into the nearshore coastal waters (Dadswell, 2006; National Marine Fisheries Service, 1998; Richmond & Kynard, 1995). In estuaries, juveniles and adults occupy areas with little or no current over a bottom composed primarily of mud and sand (Secor et al., 2000). Adults are found in deep water (10 to 30 m) in winter and in shallower habitat (2 to 10 m) during summer (Welsh et al., 2002). Juveniles are known to occur in the Study Area, particularly in the St. Johns River in Florida.

3.6.2.2.4.3 Population Trends

Shortnose sturgeon is a long-lived (average life span 30 years), riverine and estuarine habitat dependent, iteroparous, and anadromous species. Populations were stable or possibly increasing in the 1990s (Wippelhauser et al., 2015). Certain subpopulations have increased in recent years, particularly the Hudson River stock (Bain, 1997; Stein et al., 2004). Several strong cohorts (i.e., groups of fish born in the same year within a population or stock) had higher-than-expected survival during the 1980s and 1990s, then recovery slowed during the late 1990s (Woodland & Secor, 2007). Abundances in the Hudson River population exceed recovery criteria (Bain, 1997; Woodland & Secor, 2007). The Delaware River supports 8,445 individuals (Welsh et al., 2002).

3.6.2.2.4.4 Predator and Prey Interactions

Prey varies with season between northern and southern river systems. In northern rivers, some sturgeon feed in freshwater during summer and over sand-mud bottoms in the lower estuary during fall, winter, and spring (National Marine Fisheries Service, 1998). In southern rivers, feeding has been observed during winter at or just downstream the saltwater and freshwater interface (Kynard, 1997). In the Southeast U.S. Continental Shelf Large Marine Ecosystem, shortnose sturgeon reduces feeding activity during summer months (Sulak & Randall, 2002).

The shortnose sturgeon feeds by suctioning worms, crustaceans, molluscs, and small fish from the bottom (National Marine Fisheries Service, 1998; Stein et al., 2004). Juveniles have been found in the stomachs of yellow perch (*Perca flavescens*). Predation on sub-adults and adults is not well-documented; however, sharks are likely predators in the marine environment (National Marine Fisheries Service, 1998).

3.6.2.2.4.5 Species-Specific Threats

The population decline has been attributed to pollution, overharvest in commercial fisheries (including bycatch), and its resemblance to the formerly commercially valuable Atlantic sturgeon (Bain et al., 2007; National Marine Fisheries Service, 1998). Other risk factors include poaching, non-native species, poor water quality in spawning and nursery habitats, contaminants (e.g., heavy metals, pesticides, and organochlorine compounds), siltation from dredging, bridge construction and demolition, impingement on power plant cooling water intake screens, impoundment operations, and hydraulic dredging operations (Collins et al., 2000; National Marine Fisheries Service, 1998).

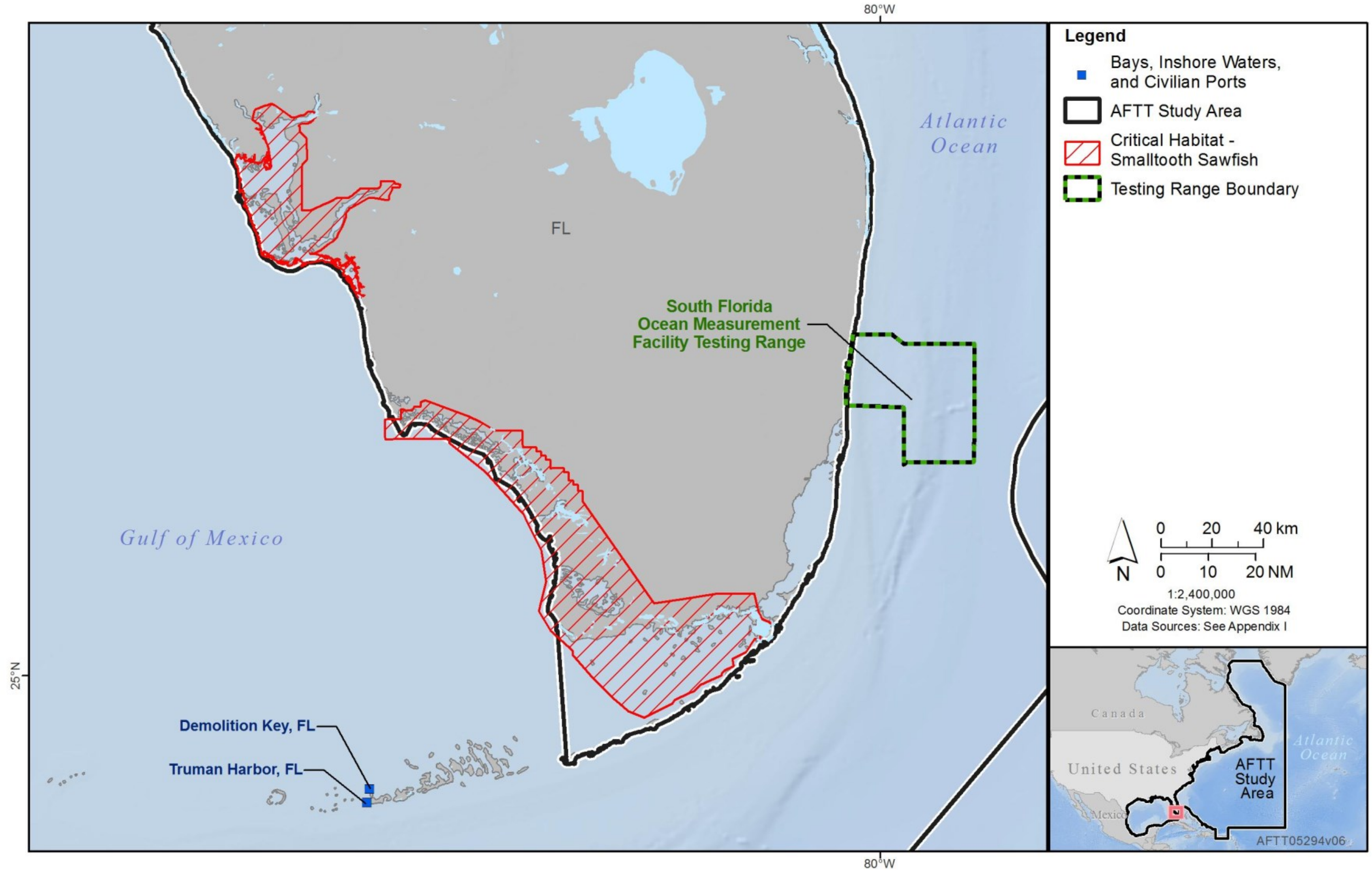
3.6.2.2.5 Smalltooth Sawfish (*Pristis pectinata*)

3.6.2.2.5.1 Status and Management

The smalltooth sawfish was once common in the Gulf of Mexico and along the east coast of the United States. Today, the severely depleted population is restricted mostly to southern Florida (Poulakis & Seitz, 2004; Simpfendorfer, 2006; Simpfendorfer et al., 2011). The Distinct Population Segment of smalltooth sawfish in the United States, between Florida and Cape Hatteras, North Carolina, was listed as endangered under the ESA by NMFS in 2003 and by USFWS in 2005 (70 *Federal Register* 69464), and it is co-managed by both agencies (National Marine Fisheries Service, 2010a).

In September 2009, NMFS designated approximately 840,472 acres in two units of critical habitat occupied by the U.S. Distinct Population Segment of smalltooth sawfish (74 *Federal Register* 45353; Figure 3.6-4). The two units determined for critical habitat designations are the Charlotte Harbor Estuary Unit, which comprises approximately 221,459 acres of habitat, and the Ten Thousand Islands/Everglades Unit, which comprises approximately 619,013 acres of habitat. The two units are located along the southwestern coast of Florida between Charlotte Harbor and Florida Bay.

These specific areas contain the following physical and biological features that are essential to the conservation of smalltooth sawfish and that may require special management considerations or protection: red mangroves and shallow euryhaline habitats characterized by water depths between the mean high water line and 3 ft. (0.9 m) measured at mean lower low water. The Key West Range Complex does not overlap these areas; the northeastern boundary (Warning Area- 174) of the Key West Range Complex is within approximately 9 NM of critical habitat at its closest point (Figure 3.6-4).



Note: AFTT: Atlantic Fleet Training and Testing; LME: Large Marine Ecosystem

Figure 3.6-4: Critical Habitat Areas for Smalltooth Sawfish in and Adjacent to the Study Area

3.6.2.2.5.2 Habitat and Geographic Range

The smalltooth sawfish typically inhabit shallow tropical or subtropical estuarine and marine waters associated with sandy and muddy deep holes, limestone hard bottom, coral reefs, sea fans, artificial reefs, and offshore drilling platforms (Poulakis & Seitz, 2004). Nursery areas of the smalltooth sawfish include estuaries and mangroves with the roots providing refuge from predators (National Marine Fisheries Service, 2009a, 2010a; Seitz & Poulakis, 2006; Simpfendorfer & Wiley, 2005). Juveniles exhibit a high site fidelity to nearshore areas and residence up to 55 days, and upstream movement toward preferred lower salinity conditions (Poulakis et al., 2012; Simpfendorfer et al., 2011). Larger individuals may occur to a depth of 120 m (Poulakis & Seitz, 2004; Simpfendorfer, 2006), although adults are known to spend more time in shallower habitat than in deeper waters (Simpfendorfer & Wiley, 2005).

Southeast U.S. Continental Shelf Large Marine Ecosystem. The species is recorded in the Southeast U.S. Continental Shelf Large Marine Ecosystem area of the Study Area, but its range is primarily southern Florida. Historic records indicate that this species may have made summer migrations northward along the Atlantic coast.

Gulf of Mexico Large Marine Ecosystem. The smalltooth sawfish also occurs in the Gulf of Mexico Large Marine Ecosystem portion of the Study Area, particularly at river mouths (e.g., Mississippi River) (National Marine Fisheries Service, 2009a; Simpfendorfer, 2006).

3.6.2.2.5.3 Population Trends

No population estimates exist of the smalltooth sawfish. The best available data suggest that the current population is a small fraction of its historical size (National Marine Fisheries Service, 2010a; Simpfendorfer, 2006). Data collected in the Everglades National Park since 1972 suggest that the population has stabilized, and may be increasing. Between 1989 and 2004, the population increased by approximately 5 percent (Carlson et al., 2007a).

3.6.2.2.5.4 Predator and Prey Interactions

Smalltooth sawfish are nocturnal feeders and use the saw-like rostrum to disrupt the substrate to expose crustaceans and to stun and slash schooling fish. Juveniles are preyed upon by bull sharks and other shark species inhabiting shallow coastal waters (National Marine Fisheries Service, 2009a).

3.6.2.2.5.5 Species-Specific Threats

Factors contributing to the historic population decline included habitat degradation, commercial harvest, gear entanglements, bycatch in fisheries, poaching, and the illegal market for the saw-like rostrum (WildEarth Guardians, 2009).

3.6.2.2.6 Giant Manta Ray (*Manta birostris*)

3.6.2.2.6.1 Status and Management

The giant manta ray was proposed to be listed as a threatened species under the ESA by NMFS on January 12, 2017 (82 *Federal Register* 3694). Based on the best scientific and commercial information available, including the status review report (Miller & Klimovich, 2016), and after taking into account efforts being made to protect these species, NMFS determined that the giant manta ray is likely to become an endangered species within the foreseeable future throughout a significant portion of its range. On January 22, 2018, NMFS published the Final Rule listing this species as threatened and also concluded that critical habitat is not determinable because data sufficient to perform the required analyses are lacking (83 *Federal Register* 2916).

3.6.2.2.6.2 Habitat and Geographic Range

Giant manta rays are considered seasonal visitors to productive coastlines with regular upwelling, including oceanic island shores, and offshore pinnacles and seamounts. They utilize sandy bottom habitat and seagrass beds, as well as shallow reefs, and the ocean surface both inshore and offshore. The species ranges globally and is distributed in tropical, subtropical, and temperate waters They can migrate seasonally, usually more than approximately 621 mi. (1,000 km), however, they are not likely across ocean basins (National Oceanic and Atmospheric Administration, 2016a).

Northeast U.S. Continental Shelf Large Marine Ecosystem. The ecosystem is highly productive with upwelling from Cape Hatteras to the Gulf of Maine (National Oceanic and Atmospheric Administration, 2016d). Giant manta rays occur in the Northeast U.S. Continental Shelf Large Marine Ecosystem for feeding on plankton in the upwelling region.

Southeast U.S. Continental Shelf Large Marine Ecosystem. Occasional short-lived plankton blooms occur along the Gulf Stream front and in intrusions into the Southeast U.S. Continental Shelf Large Marine Ecosystem (Aquarone, 2009). This draws giant manta rays to feed in this large marine ecosystem during these occasions. Shelf fronts are separated by wintertime cold air outbreaks, river discharge, tidal mixing, and wind-induced coastal upwelling, all of which attract giant manta rays for feeding, and to seagrass floors (Aquarone, 2009).

Caribbean Sea Large Marine Ecosystem. In the Caribbean Sea Large Marine Ecosystem, there are localized upwelling areas and nearshore habitats like coral reefs, mangroves, and seagrass beds (Heileman & Mahon, 2008). All of these areas attract giant manta rays for feeding and attendance at cleaning stops on coral reefs where fishes groom the rays by eating parasites off of them (Food and Agriculture Organization of the United Nations, 2013).

Gulf of Mexico Large Marine Ecosystem. The Loop Current, which is created by oceanic waters entering the Gulf of Mexico Large Marine Ecosystem from the Yucatan channel and exiting through the Straits of Florida, has upwelling along its edges, as well as in its rings and eddies that are associated with it (Heileman & Rabalais, 2008). These rings, eddies, and upwelling zones are areas where giant manta rays could be found feeding.

3.6.2.2.6.3 Population Trends

No stock assessments exist for the giant manta ray. Most estimates of subpopulations are based on anecdotal observations by divers and fishermen, with current populations estimated between 100 and 1,500 individuals (Miller & Klimovich, 2016). Giant manta rays reach maturity at age 10 and have one pup every two to three years (National Oceanic and Atmospheric Administration, 2016a).

3.6.2.2.6.4 Predator and Prey Interactions

Manta rays prey exclusively on plankton (Defenders of Wildlife, 2015b). The gill plates of the giant manta ray filters the water as they swim, straining out any plankton that is larger than a grain of sand (Defenders of Wildlife, 2015b).

3.6.2.2.6.5 Species-Specific Threats

Threats to giant manta rays include fisheries and bycatch, destruction or modification of habitat, and disease and predation. The international market highly values the gill plates of the giant manta ray for use in traditional medicines. They also trade their cartilage and skins and consume the manta ray meat or use it for local bait. Bycatch occurs in purse seine, gillnet, and trawl fisheries as well (National Oceanic and Atmospheric Administration, 2016a). Fisheries exist outside the Study Area in Indonesia, Sri Lanka, India, Peru, Mexico, China, Mozambique, and Ghana (Food and Agriculture Organization of the United Nations, 2013). Other potential threats include degradation of coral reefs, interaction with marine debris, marine pollution, and boat strikes (Food and Agriculture Organization of the United Nations, 2013).

3.6.2.2.7 Gulf Sturgeon (*Acipenser oxyrinchus desotoi*)

3.6.2.2.7.1 Status and Management

The Gulf sturgeon and the Atlantic sturgeon are members of the same species, but do not overlap geographically. The Gulf sturgeon was federally listed in 1991 as threatened in the Gulf of Mexico Large Marine Ecosystem (56 *Federal Register* 49653) and is co-managed by NMFS and USFWS. The fishery for the species has been closed since being listed. Bycatch along the Gulf coast was a major source of mortality (U.S. Fish and Wildlife Service, 1995), and efforts to reduce bycatch include gear modifications for nearshore trawl fisheries (Smith & Clugston, 1997). NMFS and USFWS concluded that the Gulf sturgeon population was stable and had achieved recovery objectives (U.S. Fish and Wildlife Service & National Marine Fisheries Service, 2009).

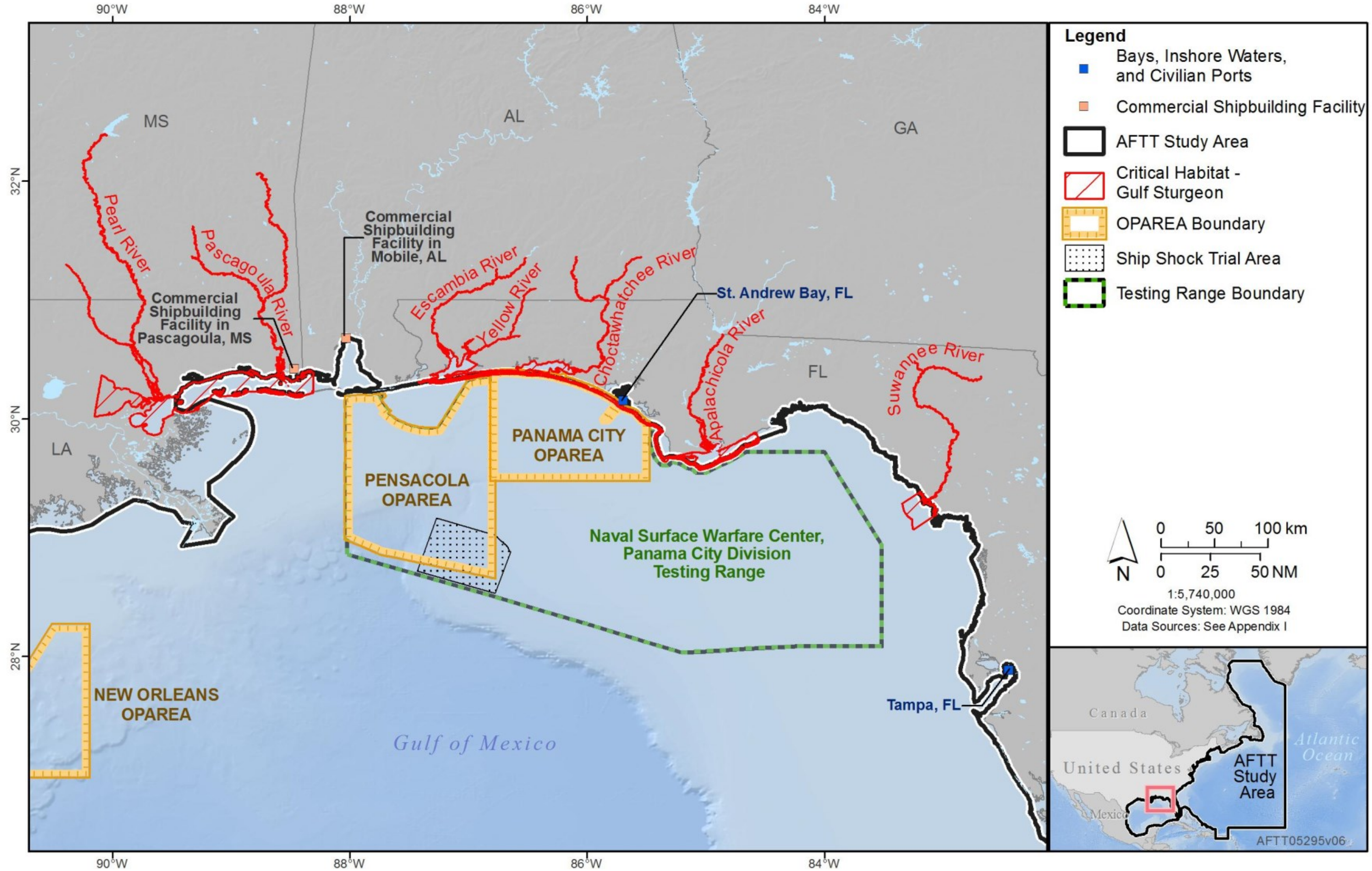
In September 2009, NMFS designated critical habitat for Gulf sturgeon within and adjacent to the states of Louisiana, Mississippi, Alabama, and Florida (82 *Federal Register* 39160; Figure 3.6-5). The physical and biological features essential for the conservation of Gulf sturgeon were determined to be those habitat components that support feeding, resting, and sheltering, reproduction, migration, and physical features necessary for maintaining the natural processes that support these habitat components.

The physical and biological features include:

1. Abundant prey items within riverine habitats for larval and juvenile life stages, and within estuarine and marine habitats and substrates for juvenile, subadult, and adult life stages;
2. Riverine spawning sites with substrates suitable for egg deposition and development, such as limestone outcrops and cut limestone banks, bedrock, large gravel or cobble beds, marl, soapstone or hard clay;
3. Riverine aggregation areas, also referred to as resting, holding, and staging areas, used by adult, subadult, and/or juveniles, generally, but not always, located in holes below normal riverbed depths, believed necessary for minimizing energy expenditures during fresh water residency and possibly for osmoregulatory functions;
4. A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of freshwater discharge over time) necessary for:

   a. Normal behavior, growth, and survival of all life stages in the riverine environment, including migration, breeding site selection, courtship, egg fertilization, resting, and staging; and

   b. Maintaining spawning sites in suitable condition for egg attachment, eggs sheltering, resting, and larvae staging; water quality, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;
5. Sediment quality, including texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; and



Note: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area

Figure 3.6-5: Critical Habitat Areas for Gulf Sturgeon in and Adjacent to the Study Area

6. Safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (e.g. a river unobstructed by any permanent structure, or a dammed river that still allows for passage).

Most features of the critical habitat are not applicable to the marine portions of the Study Area. The Panama City OPAREA and the Naval Surface Warfare Center Panama City Division Testing Range overlap with Gulf sturgeon critical habitat (Figure 3.6-5). This critical habitat (Unit 11) encompasses nearshore Gulf of Mexico waters off Escambia, Santa Rosa, Okaloosa, Walton, Bay, and Gulf counties in Florida. Unit 11 provides a migration corridor for Gulf sturgeon en route from winter habitat and feeding grounds in the Gulf of Mexico to spring and summer spawning and hatching habitat in the Yellow, Choctawhatchee, and Apalachicola rivers. Gulf sturgeon inhabit the nearshore coastline between Pensacola and Apalachicola bays, in depths of less than 6 m during winter.

3.6.2.2.7.2 Habitat and Geographic Range

Adults inhabit nearshore waters from October thru February (Robydek & Nunley, 2012) with distribution influenced by prey availability (Ross et al., 2009), particularly within the Suwannee River estuary (Harris et al., 2005). The spring spawning migration toward natal rivers begins as riverine water temperatures reach 64°F to 72°F (Edwards et al., 2003; Heise et al., 2004; Rogillio et al., 2007). Spawning areas include the Suwannee, Apalachicola, Escambia, Choctawhatchee, and Pascagoula rivers (Chapman & Carr, 1995; Craft et al., 2001; Fox et al., 2000; Wooley & Crateau, 1985). Spawning occurs during autumn in some watersheds (e.g., Suwannee) (Randall & Sulak, 2012). Once post-spawned adults leave rivers, they remain within 1,000 m of the shoreline (Robydek & Nunley, 2012) and often inhabit estuaries and nearshore bays in water less than 10 m deep (Ross et al., 2009). Some individuals, particularly females between spawning years (Fox et al., 2002; Ross et al., 2009) move into deeper offshore waters for short periods during cold weather (Sulak et al., 2009).

Sub-adult and adult foraging grounds include barrier island inlets with strong tidal currents and estuaries less than 2 m deep with clean sand substrate (Fox et al., 2002; Harris et al., 2005; Ross et al., 2009). Gulf sturgeon winter near beaches of northwestern Florida and southeast of the mouth of St. Andrew Bay (U.S. Fish and Wildlife Service & National Marine Fisheries Service, 2009), while others moved northeast of St. Andrew Bay at depths ranging from 4 to 12 m (12 to 40 ft.) at 0.5 to 2 mi. offshore, and likely feeding on prey associated with fine sand and shell hash substrates (U.S. Fish and Wildlife Service & National Marine Fisheries Service, 2009).

By December, only the young-of-the-year and juveniles remain in the rivers (Carr et al., 1996; Foster & Clugston, 1997). Young-of-the-year nursery habitat includes riverine sandbars and shoals (Carr et al., 1996). Juveniles show high site fidelity rates for riverine habitats used during spring and summer (Rudd et al., 2014), prefer sand or vegetated habitats (Wakeford, 2001), tolerate high salinity levels for extended durations, and appear to use estuaries infrequently (Sulak et al., 2009).

Gulf of Mexico Large Marine Ecosystem. This anadromous species occurs in the Gulf of Mexico Large Marine Ecosystem in bays, estuaries and rivers, and in the marine environment from Florida to Louisiana (National Marine Fisheries Service, 2010b).

3.6.2.2.7.3 Population Trends

Gulf sturgeon populations are stable or slowly increasing (U.S. Fish and Wildlife Service & National Marine Fisheries Service, 2009). Current population levels in four of the seven river systems in the recovery plan are likely at or exceeding the mean carrying capacity, given the current levels of available habitat. In the remaining three rivers, extant Gulf Sturgeon populations are likely below their estimated carrying capacity levels (Ahrens & Pine, 2014). Population estimates in the Pearl and Pascagoula rivers are lacking because research has been limited since hurricanes Ivan in 2004 and Katrina in 2005 (Rogillio et al., 2007).

3.6.2.2.7.4 Predator and Prey Interactions

Prey varies on life stage, but Gulf sturgeon is considered an opportunistic feeder. Adults typically do not feed while in freshwater, and may lose from 12 to 30 percent of their body weight while inhabiting rivers. In estuarine and marine habitats, they prey upon a wide range of benthic invertebrates (Florida Museum of Natural History, 2017b). Sharks are likely predators while sturgeon inhabit the marine environment (Florida Museum of Natural History, 2017b).

3.6.2.2.7.5 Species-Specific Threats

Factors contributing to the decline include overfishing and habitat loss. Threats include dams (e.g., Pearl, Alabama, and Apalachicola rivers), dredged material disposal, channel maintenance, oil and gas exploration, shrimp trawling, and poor water quality (U.S. Fish and Wildlife Service & National Marine Fisheries Service, 2009). Other threats include potential hybridization with non-native sturgeon from aquaculture farms and diseases.

3.6.2.2.8 Nassau Grouper (*Epinephelus striatus*)

3.6.2.2.8.1 Status and Management

The Nassau grouper is listed as threatened under the ESA in the Study Area (81 *Federal Register* 42268). Designation of critical habitat remains under study. Commercial and recreational landings declined in both pounds landed and average fish size from 1986 and 1991. As a result, moratoriums on take and possession were established in 1996 (National Marine Fisheries Service, 2015).

By 2000, abundance had decreased approximately 60 percent over the last three generations (Cornish & Eklund, 2003). This decline is attributed to intensive fishing efforts on or near the spawning aggregation sites (Beets & Hixon, 1994; Colin, 1992). Failure of recovery in response to fishing moratoriums combined with concerns over habitat loss have guided management efforts toward the establishment of marine protected areas as a more effective means of preserving the species and its habitat, which are typically near current and historical spawning aggregation sites (81 *Federal Register* 42268).

3.6.2.2.8.2 Habitat and Geographic Range

Nassau grouper is a long-lived, late-maturing perch-like bony fish. This species is a solitary fish apart from spawning aggregations (Starr et al., 2007). These fish inhabit high-relief coral reefs and rocky bottoms from nearshore to a depth of 100 m and rest on or near the bottom, with juveniles inhabiting seagrass beds and patch reefs (Bester, 2012). This species also occupies caves and large overhangs (National Marine Fisheries Service, 2015). Spawning aggregation sites are typically located near significant geomorphological features, such as projections (promontories) of the reef as little as 50 m from the shore (81 *Federal Register* 42268).

Nassau grouper congregate in large numbers at specific areas to spawn after the appropriate water temperature and moon phase cues (usually within a period of 10 days overlapping the full moon) between January and February (Archer et al., 2012; National Marine Fisheries Service, 2015; Semmens et al., 2006). Spawning aggregations of several thousand individuals have been reported (Bester, 2012).

Southeast U.S. Continental Shelf Large Marine Ecosystem. The geographic range within Study Area is limited to the southeast coast of Florida.

Gulf of Mexico Large Marine Ecosystem. Within the Study Area, Nassau grouper occur in Flower Gardens Bank; Dry Tortugas National Park; and Key West, Florida (Bester, 2012).

Caribbean Sea Large Marine Ecosystem. Range within the Study Area includes Florida and areas near Puerto Rico.

3.6.2.2.8.3 Population Trends

The current worldwide population of Nassau grouper is approximately 10,000 individuals and continues to decline (Cornish & Eklund, 2003). Subpopulations in the United States appear stable, but Caribbean stocks are in decline. Deoxyribonucleic acid (DNA) analyses indicate no evidence of genetically distinct subpopulations; thus, Nassau grouper are considered as a single population (Bernard et al., 2012; Cornish & Eklund, 2003). More recent research has shown strong genetic differentiation in subpopulations in the Caribbean that may correlate to larvae dispersal barriers (Jackson et al., 2014).

3.6.2.2.8.4 Predator and Prey Interactions

Nassau groupers are preyed upon by barracuda (*Sphyraena barracuda*), king mackerel (*Scomberomorus cavalla*), moray eels (*Gymnothorax* spp.), sandbar sharks (*Carcharhinus plumbeus*), great hammerhead sharks (*Sphyrna mokarran*), and although rare, other groupers (Bester, 2012).

Adult Nassau grouper is an opportunistic ambush predator, feeding on a variety of fishes, shrimps, crabs, lobsters, and octopuses (Sadovy & Eklund, 1999). Adults have been observed feeding on the invasive lionfish in the Caribbean and are currently being studied as a potential biocontrol option (Mumby et al., 2011). Nassau grouper larvae are filter and particulate feeders that prey on dinoflagellates, fish larvae, and mysids (Sadovy & Eklund, 1999).

3.6.2.2.8.5 Species-Specific Threats

Nassau grouper is sensitive to over-exploitation due to slow growth rate, late reproduction age (five-plus years), large size, and long lifespan (Morris et al., 2000; Sadovy & Eklund, 1999). The decline in population is the result of overharvest and collapse of spawning aggregations (Aguilar-Perera, 2006; Ehrhardt & Deleveaux, 2007) and is exacerbated by coastal development (Stallings, 2009).

Damage to spawning sites limits reproductive success of adults if alternative habitats are unavailable. Loss of macroalgae and seagrass beds is damaging to Nassau grouper populations, as it often results in low recruitment rates (Sadovy & Eklund, 1999).

Fishing moratoriums have been ineffective at preventing illegal harvest that occurs in Puerto Rico and other U.S. waters. Declines have also resulted from overfishing with spear guns and bycatch of juvenile in fine mesh nets (National Marine Fisheries Service, 2015).

The marine isopod *Excorallana tricornis* is a known parasite of the Nassau grouper, sometimes resulting in infestations immediately following spawning (Semmens et al., 2006).

3.6.2.2.9 Oceanic Whitetip Shark (*Carcharhinus longimanus*)

3.6.2.2.9.1 Status and Management

NMFS completed a comprehensive status review of the oceanic whitetip shark and, based on the best scientific and commercial information available, including the status review report (Young et al., 2016), proposed on December 29, 2016 that this species warrants listing as a threatened species under the ESA

(81 *Federal Register* 96304). On January 30, 2018, NMFS published the Final Rule listing this species as threatened and also concluded that critical habitat is not determinable because data sufficient to perform the required analyses are lacking (83 *Federal Register* 4153).

3.6.2.2.9.2 Habitat and Geographic Range

Oceanic whitetip sharks are found worldwide in warm tropical and subtropical waters between the 20° North and 20° South latitude near the surface of the water column (Young et al., 2016). In the Western Atlantic, oceanic whitetips occur from Maine to Argentina, including the Caribbean and Gulf of Mexico. This species has a clear preference for open ocean waters, with abundances decreasing with greater proximity to continental shelves. Preferring warm waters near or over 20° C (68° F), and offshore areas, the oceanic whitetip shark is known to undertake seasonal movements to higher latitudes in the summer (National Oceanic and Atmospheric Administration, 2016e) (National Oceanic and Atmospheric Administration, 2016e) and may regularly survey extreme environments (deep depths, low temperatures) as a foraging strategy (Young et al., 2016). The presence of oceanic whitetip sharks increases further away from the continental shelf in deep water areas, but the species prefers to inhabit the surface waters in deep water areas at less than 328 ft. (Defenders of Wildlife, 2015a).

Newfoundland-Labrador Shelf Large Marine Ecosystem. During warming periods, the oceanic whitetip shark may be present. Long-term steady warming has been observed in the ecosystem since 1957 and has accelerated since the mid-1990s, with the sea surface temperature rising by 1.8° C in 15 years from 4.6° C to 6.4° C (Aquarone & Adams, 2009). As the sea temperature increases, the oceanic whitetip shark would be more likely to occur in this area.

Northeast U.S. Continental Shelf Large Marine Ecosystem. The oceanic whitetip shark has declined in the northwest Atlantic and western central Atlantic (Baum et al., 2015). It could occur in the offshore open ocean areas.

Southeast U.S. Continental Shelf Large Marine Ecosystem. Oceanic whitetip sharks would be more likely to occur far offshore in the open sea in waters that are 200 m deep near the surface of the water column, although some have been recorded to occur at depths of 152 m (Baum et al., 2015).

Caribbean Sea Large Marine Ecosystem. The oceanic whitetip shark would occur in the open ocean offshore portions of the Caribbean Sea Large Marine Ecosystem. They would occur near the surface of the water column of 200 m deep or deeper areas in the ecosystem area (Baum et al., 2015). Sharks would be less likely to occur in the shallow habitats such as coral reefs, mangroves, and seagrass beds (Heileman & Mahon, 2008).

Gulf of Mexico Large Marine Ecosystem. Oceanic whitetip sharks are a species that prefers warmer waters, and is more likely to occur during the summer months (Baum et al., 2015). This species would likely occur near the surface of deep open ocean waters offshore. An analysis of the Gulf of Mexico used U.S. pelagic longline surveys in the mid-1950s and U.S. pelagic longline observer data in the late-1990s and estimated a decline of the species in the Gulf over the 40-year time period. However, due to temporal changes in fishing gear and practices over the time period, the study may have exaggerated or underestimated the magnitude of population decline (Baum et al., 2015).

3.6.2.2.9.3 Population Trends

Population trend information is not clear or available. Information shows that the population has declined and that there is evidence of decreasing average weights of the sharks that have been encountered. The oceanic whitetip shark population has declined by 70 percent throughout the Atlantic region (Defenders of Wildlife, 2015a).

3.6.2.2.9.4 Predator and Prey Interactions

As one of the major apex predators in the tropical open ocean waters, the oceanic whitetip shark feeds on fishes and cephalopods. As a high level predators, the oceanic whitetip shark, with its large size (Ebert et al., 2015) and long life, builds up high levels of pollutants due to bioaccumulation and bio-magnification impacting their physiology negatively (Defenders of Wildlife, 2015a).

3.6.2.2.9.5 Species-Specific Threats

Threats include pelagic longline and drift net fisheries bycatch, targeted fisheries (for the shark fin trade), and threatened destruction or modification of its habitat and range (Baum et al., 2015; Defenders of Wildlife, 2015a). Legal and illegal fishing activities in the Atlantic have caused significant population declines for the oceanic whitetip shark. It is caught as bycatch in tuna and swordfish longlines in the northwest Atlantic and Gulf of Mexico. Habitat degradation has occurred due to pollutants in the environment that bioaccumulate and biomagnify to high levels in their bodies due to their high position in the food chain, long life, and large size (Defenders of Wildlife, 2015a).

3.6.2.2.10 Scalloped Hammerhead Shark (*Sphyrna lewini*)

3.6.2.2.10.1 Status and Management

The Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead population are listed as threatened under the ESA (79 *Federal Register* 52576). The Northwest Atlantic and Gulf of Mexico Distinct Population Segment of scalloped hammerhead sharks has not been listed under the ESA at this time. There are no designated critical habitat marine areas within the jurisdiction of the United States.

The scalloped hammerhead shark fishery is managed under the Large Coastal Shark Management Unit by NMFS through the Final Consolidated Atlantic Highly Migratory Species Fisheries Management Plan (Miller et al., 2013).

3.6.2.2.10.2 Habitat and Geographic Range

The scalloped hammerhead shark is a coastal and semi-oceanic species distributed in temperate to tropical waters (Froese & Pauly, 2016). Scalloped hammerhead sharks inhabit the surface to depths of 275 m (Duncan & Holland, 2006) of the Study Area. Coastal waters with temperatures between 23°C and 26°C are preferred habitats (Castro, 1983; Compagno, 1984), with animals generally remaining close to shore during the day and moving into deeper waters to feed at night (Bester, 1999). Ketchum et al. (2014b) found scalloped hammerheads formed daytime schools at specific locations in the Galapagos Islands, but dispersed at night, spending more time at the northern islands during part of the warm season (December–February) compared to the cool. Ketchum et al. (2014a) used acoustic telemetry to show that scalloped hammerheads were highly selective of location (i.e., habitat on up-current side of island) and depth (i.e., top of the thermocline) while refuging, where they may carry out essential activities such as cleaning and thermoregulation, and also perform exploratory vertical movements by diving the width of the mixed layer and occasionally diving below the thermocline while moving offshore, most likely for foraging. Hoffmayer et al. (2013) also found that tagged sharks exhibited consistent and repeated diel vertical movement patterns, making more than 76 deep nighttime dives to a maximum depth of 964 m, possibly representing feeding behavior. A genetic marker study suggests that females remain close to coastal habitats, while males disperse across larger open ocean areas (Daly-Engel et al., 2012).

In the western Atlantic, their range extends from New Jersey to points south of the Study Area, including the Gulf of Mexico and the Caribbean Sea (Bester, 1999) with seasonal migration along the eastern United States. Juveniles rear in coastal nursery areas (Duncan & Holland, 2006) with all ages occurring in the Gulf Stream, but rarely inhabits the open ocean (Kohler & Turner, 2001). Scalloped hammerhead sharks that are part of the Central and Southwest Atlantic Distinct Population Segment are only found in the southernmost portion of the Study Area in the vicinity of Puerto Rico. Scalloped hammerhead sharks that occur in other portions of the Study Area are not protected under the ESA.

3.6.2.2.10.3 Population Trends

The scalloped hammerhead shark has undergone substantial declines throughout its range (Baum et al., 2003). There is some evidence of population increase in the Southeast U.S. Continental Shelf Large Marine Ecosystem (Ward-Paige et al., 2012). Landings of scalloped hammerhead sharks peaked at 8,000 metric tons in 2002 and declined to 1,000 metric tons in 2009 (Food and Agriculture Organization of the United Nations, 2005, 2009). Modeling results estimate the overall population range from approximately 142,000 to 169,000 individuals in 1981 and between 24,000 and 28,000 individuals in 2005 (Miller et al., 2013).

3.6.2.2.10.4 Predator and Prey Interactions

Scalloped hammerhead sharks have few predators. Sharks locate potential prey by odor, particularly from injured prey, or low-frequency sounds, inner ear (vibrations), lateral line (turbulence) with vision coming into play at closer range (Moyle & Cech, 2004). They feed primarily at night (Compagno, 1984) on a wide variety of fishes such as sardines, herring, anchovies, and jacks, and also feed on invertebrates, including squid, octopus, shrimp, crabs, and lobsters (Bester, 1999).

3.6.2.2.10.5 Species-Specific Threats

The primary threat is from fishing mortality by the foreign commercial shark fin fishery (Miller et al., 2013). Longline mortality is estimated between 91 and 94 percent (National Marine Fisheries Service, 2011) total shark bycatch in the swordfish and tuna longline fisheries and shrimp trawls in the Gulf of Mexico (Branstetter, 2002). This species is highly susceptible to bycatch due to schooling habits (Food and Agriculture Organization of the United Nations, 2012).

3.6.2.2.11 Alewife (*Alosa pseudoharengus*)

3.6.2.2.11.1 Status and Management

In August 2017, NMFS announced the initiation of a new status review of alewife to determine whether listing this species as endangered or threatened under the ESA is warranted (82 *Federal Register* 38672).

3.6.2.2.11.2 Habitat and Geographic Range

Alewife typically occur over the continental shelf in waters less than 328 ft. (100 m) (Neves, 1981). This species spawns in a variety of habitats, ranging from swift moving rivers to small tributaries above the tidal zone (National Marine Fisheries Service, 2009c).

Northeast U.S. Continental Shelf Large Marine Ecosystem and Southeast U.S. Continental Shelf Large Marine Ecosystem. Alewife range throughout the Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems from Newfoundland to North Carolina (historically to South Carolina) (National Marine Fisheries Service, 2009c). Alewife are anadromous, migrating during the spring months to spawn in their natal rivers on the U.S. east coast then returning to coastal waters in the summer. Juveniles mature for several years in coastal waters before making their first spawning run. Alewife are highly migratory and travel in large schools near the surface (National Marine Fisheries Service, 2009c).

3.6.2.2.11.3 Population Trends

Alewife have undergone substantial declines throughout most of their range. At Holyoke Dam on the Connecticut River, the total migration has dropped from about 600,000 individuals in 1985 to only 1,300 individuals in 2003 (National Marine Fisheries Service, 2009c). Similar trends have been observed in Rhode Island, Massachusetts, and North Carolina. The Rhode Island Department of Environmental Management reported a 95 percent decline in runs between 2000 and 2004. Similarly, alewife runs in the St. Croix River were reduced from a high of 2,624,000 fish in 1987 to 1,299 fish in 2004 (National Marine Fisheries Service, 2009b).

3.6.2.2.11.4 Predator and Prey Interactions

All life stages of alewife feed primarily on phytoplankton and zooplankton, but adults also eat mysids, small finfish, and benthic crustaceans (National Marine Fisheries Service, 2009b). This species is preyed on by a number of marine species, including striped bass, bluefish, tunas, cod, haddock, halibut, American eel, seabirds, and mammals.

3.6.2.2.11.5 Species-Specific Threats

Alewife have been species of concern, and now an ESA candidate, because of substantial declines in populations throughout their ranges. Hydroelectric facilities (dams) with poor fish passage restrict their access to spawning and forage areas. Fish are also injured or killed by hydroelectric turbines. Degradation of water quality by toxic pollutants, nutrient discharge, and sediment loads may have also contributed to the decline of river herring. In addition, commercial marine fishing pressure exacerbates the riverine threats to this species (76 *Federal Register* 67652).

3.6.2.2.12 Blueback Herring (*Alosa aestivalis*)

3.6.2.2.12.1 Status and Management

In August 2017, NMFS announced the initiation of a new status review of blueback herring to determine whether listing this species as endangered or threatened under the ESA is warranted (82 *Federal Register* 38672). Blueback herring exhibit very similar life histories to alewife (Section 3.6.2.2.11), and are often harvested and managed together because of the difficulty in distinguishing between the two species.

3.6.2.2.12.2 Habitat and Geographic Range

Blueback herring typically occur over the continental shelf in waters less than 328 ft. (100 m) (Neves, 1981). This species spawns in a variety of habitats, ranging from swift moving rivers to small tributaries above the tidal zone (National Marine Fisheries Service, 2009c).

Northeast U.S. Continental Shelf Large Marine Ecosystem and Southeast U.S. Continental Shelf Large Marine Ecosystem. The blueback herring ranges throughout the Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems from Nova Scotia to the St. Johns River, Florida (McBride et al., 2010). Blueback herring are anadromous, migrating during the spring months to spawn in their natal rivers on the U.S. east coast then returning to coastal waters in the summer. Juveniles mature for several years in coastal waters before making their first spawning run. This species is highly migratory and travels in large schools near the surface (National Marine Fisheries Service, 2009c).

3.6.2.2.12.3 Population Trends

Blueback herring have undergone substantial declines throughout most of their range. At Holyoke Dam on the Connecticut River, the total migration has dropped from about 600,000 individuals in 1985 to only 1,300 individuals in 2003 (National Marine Fisheries Service, 2009c). Similar trends have been observed in Rhode Island, Massachusetts, and North Carolina. The Rhode Island Department of Environmental Management reported a 95 percent decline in runs between 2000 and 2004.

3.6.2.2.12.4 Predator and Prey Interactions

All life stages of blueback herring feed primarily on phytoplankton and zooplankton, but adults also eat mysids, small finfish, and benthic crustaceans (National Marine Fisheries Service, 2009c). This species is preyed on by a number of marine species, including striped bass, bluefish, tunas, cod, haddock, halibut, American eel, seabirds, and mammals.

3.6.2.2.12.5 Species-Specific Threats

Blueback herring have been species of concern, and now an ESA candidate, because of substantial declines in populations throughout their ranges. Hydroelectric facilities (dams) with poor fish passage restrict their access to spawning and forage areas. Fish are also injured or killed by hydroelectric turbines. Degradation of water quality by toxic pollutants, nutrient discharge, and sediment loads may have also contributed to the decline of river herring. In addition, commercial marine fishing pressure exacerbates the riverine threats to this species (76 *Federal Register* 67652).

3.6.2.2.13 Cusk (*Brosme brosme*)

3.6.2.2.13.1 Status and Management

The cusk was added to the Candidate Species List by NMFS on March 9, 2007 (72 *Federal Register* 10710). NMFS is in the process of a status review for the cusk and soliciting scientific and commercial information pertaining to the species.

3.6.2.2.13.2 Habitat and Geographic Range

Cusk inhabit small shoals on rock, pebble, and gravel bottoms at depths between 60 and 1,805 ft. (20 and 550 m) (Collette & Klein-MacPhee, 2002) and temperatures ranging from 32°F to 50°F (0°C to 10°C) (National Marine Fisheries Service, 2009d). Cusk eggs are buoyant; after hatching, larvae remain near the surface, then settle to the bottom as 2 in. (5 cm) juveniles (Fisheries and Oceans Canada, 2004). Adult cusk are solitary and remain in offshore waters; they are rarely captured in waters less than 65 to 100 ft. (20 to 30 m) deep (Knutsen et al., 2009). Unlike other cods, cusk rarely leave the seafloor, and do not disperse very far once settled into a particular habitat area (Collette & Klein-MacPhee, 2002).

Scotian Shelf Large Marine Ecosystem. The cusk occurs around the Scotian Shelf Large Marine Ecosystem (National Marine Fisheries Service, 2009d).

Newfoundland-Labrador Shelf Large Marine Ecosystem. Cusks occur around the Strait of Belle Isle and on the Grand Banks of Newfoundland in the Newfoundland-Labrador Shelf Large Marine Ecosystem (National Marine Fisheries Service, 2009d), and infrequently at the southern tip of Greenland in the Labrador Current Open Ocean Area (National Marine Fisheries Service, 2009d).

Northeast U.S. Continental Shelf Large Marine Ecosystem. The cusk is limited geographically by its need for cold water; it ranges only as far south as the Northeast U.S. Continental Shelf Large Marine Ecosystem around New Jersey (National Marine Fisheries Service, 2009d).

3.6.2.2.13.3 Population Trends

Fisheries data indicate substantial decreases in biomass and abundance of cusk, most likely because of fishery harvest; U.S. landings dropped from approximately 4,200 tons (3,800 metric tons) in the early 1980s to 87 tons (79 metric tons) in the year 2004 (Collette & Klein-MacPhee, 2002; National Marine Fisheries Service, 2009d). Very little fisheries-independent data exists for this species.

3.6.2.2.13.4 Predator and Prey Interactions

The cusk feeds primarily on crustaceans and shellfish, fishes (including flatfish and gurnard), and occasionally on sea stars. However, little information is available on its diet because most cusk have emptied their stomach contents by the time they reach the surface, making stomach-content analysis very difficult (Fisheries and Oceans Canada, 2004). The primary food composition (by percent weight) is crustaceans (51 percent), fishes (16 percent), and echinoderms (15 percent), with some variation by region (Collette & Klein-MacPhee, 2002). The most frequent predator of cusk are spiny dogfish (*Squalus acanthias*), but other fishes (cods, hakes, skates, and flounders) and marine mammals (hooded seal [*Cystophora cristata*] and grey seal [*Halichoerus grypus*]) also feed on cusk (Collette & Klein-MacPhee, 2002).

3.6.2.2.13.5 Species-Specific Threats

Threats to cusk are poorly understood. Bycatch of cusk by commercial fisheries targeting cod and haddock is likely the primary cause of decline in both the United States and Canada (Fisheries and Oceans Canada, 2004; National Marine Fisheries Service, 2009d). Canada established a bycatch limit of 1,000 tons of cusk in 1999 and reduced it to 750 tons of cusk in 2003 (Crozier et al., 2004). Deepwater seismic testing within cusk habitat by the oil and gas industry could impact fish closely associated with the seafloor (Fisheries and Oceans Canada, 2011).

3.6.2.2.14 Dwarf Seahorse (*Hippocampus zosterae*)

3.6.2.2.14.1 Status and Management

The dwarf seahorse was added to the Candidate Species List by NMFS on May 4, 2012 (77 *Federal Register* 26478).

3.6.2.2.14.2 Habitat and Geographic Range

The dwarf seahorse has a restricted geographic range within the Study Area, inhabiting tropical and subtropical/warm-temperate waters of Florida, the Gulf of Mexico, and the Caribbean (Masonjones & Lewis, 1996). It primarily occurs in south Florida estuaries and in the Florida Keys. The dwarf seahorse prefers protected bays/lagoons with low water flow, high organic content, mid- to high-salinities and depths less than 6 ft. (Bruckner, 2005; Foster & Vincent, 2004). The species is almost exclusively associated with seagrass beds, particularly eelgrass (*Zostera* spp.) (Bruckner, 2005). It is more abundant in areas with higher seagrass density, canopy cover, and seagrass shoot density (Bruckner, 2005). Other habitats used by the dwarf seahorse include mangrove areas, unattached algae, and inshore drifting vegetation (Center for Biological Diversity, 2011; Hoese & Moore, 1998; Tabb & Manning, 1961).

While most seahorse species exhibit strong site-fidelity, in terms of home ranges and spawning habitat (Curtis & Vincent, 2006; Masonjones & Lewis, 1996), Masonjones et al. (2010) suggest that further seahorse dispersal outside of home ranges may occur. Dispersal may be enhanced by clinging to drifting Sargassum or floating debris within inshore habitats (Curtis & Vincent, 2006; Masonjones & Lewis, 1996). Spawning occurs between February and November (Foster & Vincent, 2004).

Southeast U.S. Continental Shelf Large Marine Ecosystem. The dwarf seahorse's primary range includes south Florida estuaries and the Florida Keys (77 *Federal Register* 26478).

Gulf of Mexico Large Marine Ecosystem. Bruckner et al. (2005) report that the dwarf seahorse is uncommon in many areas in the Gulf of Mexico (77 *Federal Register* 26478), with fewer than 20 independent collection records from the following locations: Lower Laguna Madre, South Apalachee Bay, North Apalachee Bay, Corpus Christi Bay, St. George Sound, East Mississippi Sound, Aransas Bay, Terrebonne/Timbalier Bays, Chandeleur Sound, Perdido Bay, and Pensacola Bay (Beck & Odaya, 2001).

Caribbean Sea Large Marine Ecosystem. The dwarf seahorse's primary range includes all portions of the Caribbean (77 *Federal Register* 26478).

3.6.2.2.14.3 Population Trends

There are no published data on current global population trends or total numbers of mature dwarf seahorses; however, some population data exist in Florida based on numbers derived from the commercial seahorse fishery. NMFS reported a five-fold increase in seahorse landings between 1991 and 1992 (from 14,000 harvested in 1991 to 83,700 harvested in 1992), with the increased landings primarily attributed to dwarf seahorses (77 *Federal Register* 26478). Over a longer period, the number of dwarf seahorses landed during 1990 to 2003 ranged from 2,142 to 98,779 individuals per year (Bruckner, 2005). Additional density data are from ichthyoplankton tows conducted in portions of southern Florida and range from 0 to 6 seahorses per 100 cubic meters in subtidal pools, seagrass beds, in channels, and along restored marsh edges (Masonjones et al., 2010; Powell et al., 2002).

3.6.2.2.14.4 Predator and Prey Interactions

Seahorses are ambush predators, consuming primarily live, mobile nekton, such as small amphipods and other invertebrates (Bruckner, 2005).

3.6.2.2.14.5 Species-Specific Threats

Dwarf seahorses are the second most sought after fish exported from Florida in the aquarium trade (77 *Federal Register* 26478). They are dried and sold at curio shops as souvenirs (Bruckner, 2005) and also are in high demand in the traditional Chinese medicine trade (77 *Federal Register* 26478).

The petition for listing (Center for Biological Diversity, 2011) describes other natural or manmade factors that may be threatening the dwarf seahorse, including life history characteristics, bycatch mortality, illegal fishing, hurricanes or tropical storms, and invasive species. The petition also suggests that the current status of the dwarf seahorse may be related to low-frequency boat motor noise, based on a single lab study (77 *Federal Register* 26478). However, the actual negative impacts of boat motor noise on the health, behavior, and reproductive success of wild populations of dwarf seahorses in their natural habitat remain unclear at this time (77 *Federal Register* 26478).

In addition to species-specific threats, threats to the dwarf seahorse's primary habitat of seagrass are further described in Section 3.3.2.3.8 (Seagrasses, Cordgrasses, and Mangroves). Additional information on threats to dwarf seahorses are detailed by NMFS and Center for Biological Diversity (Center for Biological Diversity, 2011).

3.6.2.3 Species Not Listed under the Endangered Species Act

Taxonomic categories of major fish groups are provided in Table 3.6-2 and are described further in this section to supplement information on fishes of the Study Area that are not ESA-protected species. These fish groups are based on the organization presented by Moyle and Cech (2004), Nelson et al. (2016), Helfman et al. (2009), and Froese and Pauly (2016). These groupings are intended to organize the extensive and diverse list of fishes that occur in the Study Area and serve as a means to structure the analysis of potential impacts on fishes with similar physiological characteristics and habitat use. For example, numerous inshore fish taxonomic groups represented in Table 3.6-2 are found within diverse habitats in Chesapeake Bay, including striped bass, Atlantic croaker, bluefish, and shad. Exceptions to these generalizations exist within each group and are noted wherever appropriate in the analysis of potential impacts. For simplicity, the fishes are presented in generally accepted evolutionary order.

Table 3.6-2: Major Taxonomic Groups of Fishes in the Atlantic Fleet Training and Testing Study Area

Major Fish Groups			*Occurrence in the Study Area*		
Group Names	***Description***	***Representative Species***	***Open Ocean***	***Large Marine Ecosystems***	***Inshore Waters***
Jawless fishes (Orders Myxiniformes and Petromyzontiformes)	Primitive, cartilaginous, eel-like vertebrates, parasitic or feed on dead fish	Hagfishes, Lampreys	Seafloor	Seafloor	Water column, seafloor
Ground Sharks, Mackerel Sharks, Carpet Sharks, and Bullhead Sharks (Orders Carcharhiniformes, Lamniformes, Orectolobiformes, and Heterodontiformes)	Cartilaginous, two dorsal fins or first large, an anal fin, and five gill slits	Great white, Oceanic whitetip, Scalloped and smooth hammerheads, Tiger sharks, sand tiger sharks, nurse sharks, whale sharks	Water column, Seafloor	Water column, Seafloor	Water column
Frilled and Cow Sharks, Sawsharks, Dogfish, and Angel Sharks (Orders Hexanchiformes, Pristiophoriformes, Squaliformes, and Squatiniformes)	Cartilaginous, anal fin and nictitating membrane absent, 6-7 gill slits	Dogfish, Frill, Sawshark, Sevengill, Sixgill sharks	Water column, Seafloor	Water column, Seafloor	Seafloor
Stingrays, Sawfishes, Skates, Guitarfishes, and Electric Rays (Orders Myliobatiformes, Pristiformes, Rajiformes, and Torpediniformes)	Cartilaginous, flat-bodied, usually five gill slits	Caribbean, Electric, Giant manta rays, Largetooth and smalltooth sawfishes, Stingrays, Thorny skate	Water column, Seafloor	Water column, Seafloor	Water column, seafloor

Table 3.6-2: Major Taxonomic Groups of Fishes in the Atlantic Fleet Training and Testing Study Area (continued)

Major Fish Groups			*Occurrence in the Study Area*		
Group Names	***Description***	***Representative Species***	***Open Ocean***	***Large Marine Ecosystems***	***Inshore Waters***
Ratfishes (Order Chimaeriformes).	Cartilaginous, placoid scales	Chimaera, Rabbitfish Ratfishes	Seafloor	Seafloor	N/A
Sturgeons (Order Acipenseriformes)	Primitive, ray-finned, cartilaginous, bony plates, heterocercal tail	Atlantic, Gulf, Shortnose	N/A	Surface, water column, seafloor	Surface, water column, seafloor
Gars (Order Lepisosteiformes)	Primitive, slender body. ganoid scales, heterocercal tail; needle-like teeth	Alligator Longnose and Shortnose	N/A	N/A	Surface, water column
Herrings and allies (Order Clupeiformes)	Silvery, Lateral line on body and fin spines absent, usually scutes along ventral profile	Alabama shad. Anchovies, Herrings, Shads	N/A	Surface, water column	Surface, water column
Tarpons and allies (Orders Elopiformes, and Albuliformes)	Body encased in silvery scales, mouth large, mostly a single dorsal fin, some with tapered tail fin, spines absent	Bonefishes, Ladyfish, Malacho, Tarpons	Water column, seafloor	Surface, water column	Surface, water column, seafloor
Eels and allies (Orders Anguilliforms, Notacanthiformes, and Saccopharyngiformes)	Body very elongate, usually scaleless with pelvic fins and fin spines absent	American, Conger, Cutthroat, Duckbill, Halosaur, Morays, Pike, Sawtooth, Short-tailed, Spiny, Gulper, Pelican	Water column, seafloor	Water column, seafloor	Water column, seafloor
Salmonids (Order Salmoniformes)	Silvery body, adipose fin present	Arctic char, Atlantic salmon, Atlantic whitefish	Surface, water column	Surface, water column	Surface, water column

Table 3.6-2: Major Taxonomic Groups of Fishes in the Atlantic Fleet Training and Testing Study Area (continued)

Major Fish Groups			*Occurrence in the Study Area*		
Group Names	***Description***	***Representative Species***	***Open Ocean***	***Large Marine Ecosystems***	***Inshore Waters***
Argentines and allies (Order Argentiniformes)	Body silvery, and elongate; fin spines absent, adipose fin sometimes present, pelvic fins and ribs sometimes absent	Barreleyes, Deep-sea smelts, Slickheads, Tubeshoulders	Water column, seafloor	Seafloor	N/A
Catfishes (Order Siluriformes)	Barbels on head, spines on dorsal and pectoral fins, scaleless, adipose fin present	Sea Catfishes	N/A	Seafloor	Seafloor
Bristlemouths and allies (Orders Stomiiformes)	Photophores present, adipose and chin barbels fin sometimes present	Dragonfishes, Fangjaws, Hatchetfishes, Lightfishes,	Water column, seafloor	N/A	N/A
Greeneyes and allies (Order Aluopiformes)	Upper jaw protrusible adipose fin present, forked tail usually present	Barracudinas, Daggertooth, Greeneyes, Lizardfishes, Pearleyes, Waryfishes	Surface, water column, seafloor	Water column, seafloor	N/A
Lanternfishes and allies (Order Myctophiformes)	Small-sized, adipose fin, forked tail and photophores usually present	Lanternfishes	Water column, seafloor	N/A	N/A
Hakes and allies (Order Gadiformes)	Long dorsal and anal fins; no true spines, spinous rays present in dorsal fin, barbels present	Cods, Codlings, Cusk, Grenadiers, Hakes, Whiptails	Water column, seafloor	Water column, seafloor	Surface, water column, seafloor
Brotulas and allies (Order Ophidiiformes)	Pelvic absent or far forward and filamentous,	Brotulas, Cusk-eels	Water column, seafloor	Water column, seafloor	Water column, seafloor

Table 3.6-2: Major Taxonomic Groups of Fishes in the Atlantic Fleet Training and Testing Study Area (continued)

Major Fish Groups			Occurrence in the Study Area		
Group Names	**Description**	**Representative Species**	**Open Ocean**	**Large Marine Ecosystems**	**Inshore Waters**
	no sharp spines, Dorsal and anal fins joined to caudal fins				
Toadfishes and allies (Order Batrachoidiformes)	Body compressed; head large, mouth large with tentacles; two dorsal fins, the first with spines	Toadfish, Midshipman	N/A	Seafloor	Seafloor
Anglerfishes and allies (Order Lophiiformes)	Body globulose, first spine on dorsal fin usually modified, pelvic fins usually absent	Anglerfishes, Footballfishes, Frogfishes, Goosefishes, Sea devils	Water column, seafloor	Seafloor	Seafloor
Flying Fishes (Order Beloniformes)	Jaws extended into a beak; pelvic fins very large wing-like; spines absent	Flying fishes, Halfbeaks, Needlefishes Sauries	Surface, water column	Surface, water column	Surface, water column
Killifishes (Order Cyprinodontiformes)	Protrusible upper jaw; fin spines rarely present; single dorsal fin	Goldenspot, Killifishes, Rivulines, Sheepshead Minnows	N/A	N/A	Water column
Silversides (Order Atheriniformes)	Small-sized, silvery stripe on sides, pectoral fins high, first dorsal fin with flexible spine, pelvic fin with one spine	Atlantic, Beach, Inland, Rough,	N/A	Surface, water column	Surface, water column
Opahs and allies (Order Lampriformes)	Upper jaw protrusible; pelvic fins forward on body, below or just behind	Crestfishes, Oarfishes, Opahs, Ribbonfishes, Tapertails, Tube-eyes	Water column	N/A	N/A

Table 3.6-2: Major Taxonomic Groups of Fishes in the Atlantic Fleet Training and Testing Study Area (continued)

Major Fish Groups			*Occurrence in the Study Area*		
Group Names	***Description***	***Representative Species***	***Open Ocean***	***Large Marine Ecosystems***	***Inshore Waters***
	insertion of pectoral fins				
Squirrelfishes and allies (Order Beryciformes)	Body usually round, one dorsal fin often set far back, pelvic fins absent, fin spines often present	Bigscales, Fangtooths, Pricklefish, Slimeheads, Squirrelfishes Whalefishes	Water column, seafloor	Water column, seafloor	N/A
Dories and allies (Order Zeiformes)	Body deeply compressed, protrusible jaws, spines in dorsal fin, pelvic fin spines sometimes present	Boarfishes, Dories, Oreos, Tinselfishes	Water Column, seafloor	Water column, seafloor	N/A
Pipefishes (Order Syngnathiformes)	Snout tube-like, mouth small, scales often modified bony plates	Cornetfish, Dwarf Seahorse, Snipefishes	Water Column, seafloor	Water Column, seafloor	Seafloor
Sticklebacks (Order Gasterosteiformes)	mouth small, scales often modified bony plates	Blackspotted, threespine, fourspine, ninespine sticklebacks	Water Column, seafloor	Water Column, seafloor	Seafloor
Scorpionfishes (Order Scorpaeniformes)	Usually strong spines on head and dorsal fin; cheeks with bony struts, pectoral fins usually rounded	Poachers, Sculpins, Sea robins, Snailfishes	Water Column, seafloor	Water Column, seafloor	Seafloor
Mullets (Order Mugiliformes)	Streamline body, forked tail, hard angled mouth, large scales	Striped, white, fantail, mountain mullet	Spawn in offshore waters	Surface, water column, seafloor	Surface, water column, seafloor
Perch-like Fishes and Allies (Order Perciformes)	Deep bodied, to moderately elongate, 1-2 dorsal fins,	Angelfishes, Cardinal Fishes, Drums, Grunts, Groupers,	Water column, seafloor	Surface, water column, seafloor	Water column, seafloor

Table 3.6-2: Major Taxonomic Groups of Fishes in the Atlantic Fleet Training and Testing Study Area (continued)

Major Fish Groups			Occurrence in the Study Area		
Group Names	***Description***	***Representative Species***	***Open Ocean***	***Large Marine Ecosystems***	***Inshore Waters***
	large mouth and eyes, and throracic pelvic fins	Jacks, Remoras, Snappers, Striped bass			
Wrasses and Allies (Order Perciformes)	Compressed body, scales large, well-developed teeth, usually colorful	Hogfishes, Parrotfishes, Wrasses, Damselfishes	N/A	Seafloor	Seafloor
Eelpouts and Allies (Order Perciformes)	Eel-like body, long dorsal and anal fins, pelvic fins usually absent	Gunnels, Ocean pout, Pricklebacks, Wolfeels	Seafloor	Seafloor	Seafloor
Stargazers (Order Perciformes)	Body elongated, lower jaw usually projecting beyond upper jaw, pelvic and anal fins with spines	Stargazers	Water column, seafloor	Water column, seafloor	Water column, seafloor
Blennies, Gobies, and Allies (Order Perciformes)	Body eel-like to sculpin-like, pelvic fins reduced or fused	Barfin goby, Freckled blenny, Bridled goby, Sleepers, Wormfishes	N/A	Seafloor	Seafloor
Surgeonfishes (Order Perciformes)	Body deeply compressed laterally, mouth small, scales usually small, pelvic fins with spines	Blue tang, Surgeonfishes	N/A	Seafloor	N/A
Tunas and Allies (Order Perciformes)	Large mouth, inlets and keels usually present, pelvic fins often absent or reduced, fast swimmers	Barracudas, Billfishes, Swordfishes, Tunas	Surface, water column	Surface, water column	Juvenile barracudas only

Table 3.6-2: Major Taxonomic Groups of Fishes in the Atlantic Fleet Training and Testing Study Area (continued)

Major Fish Groups			*Occurrence in the Study Area*		
Group Names	***Description***	***Representative Species***	***Open Ocean***	***Large Marine Ecosystems***	***Inshore Waters***
Butterfishes (Order Perciformes)	Snout blunt and thick, teeth small, maxilla mostly covered by bone	Ariommatids, Driftfishes, Medusafishes	Surface, water column, seafloor	Surface, water column, seafloor	N/A
Flatfishes (Order Pleuronectiformes)	Body flattened; eyes on one side of body	Flounders, Halibuts, Soles, Tonguefishes	Seafloor	Seafloor	Seafloor
Pufferfishes (Order Tetraodontiformes)	Skin thick or rough sometimes with spines or scaly plates, pelvic fins absent or reduced, small mouth with strong teeth coalesced into biting plate	Filefishes, Ocean sunfishes, Triggerfishes	Water column	Surface, water column, seafloor	Surface, water column, seafloor

Note: N/A = not applicable

3.6.2.3.1 Jawless Fishes-Hagfishes (Order Myxiniformes) and Lampreys (Order Petromyzontiformes)

Hagfishes and lampreys are primitive, cartilaginous, vertebrates with very limited external features often associated with fishes, such as fins and scales (Helfman et al., 2009). Both groups inhabit marine water column and soft bottom seafloor habitats in depths greater than 30 m and below 13° C in the West Greenland Shelf, Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems.

Hagfish reproduction and early development has not been observed and captive breeding has been unsuccessful (Powell et al., 2005). Females lay leathery eggs on the seafloor and when the eggs hatch they are essentially miniature adults. Hagfishes prey on dying fishes or feed on dead fishes. Some hagfishes have commercial fishery importance as their external "skin" is used for making "eel leather" goods.

Lampreys are anadromous and larvae are buried in the soft bottoms of river backwaters (Moyle & Cech, 2004). Juvenile lampreys filter feed on algae and detritus. Adults are parasitic and use their oral disc mouth to attach to other fishes and feed on their blood (Moyle & Cech, 2004; Nelson et al., 2004). Hagfishes and lampreys have no known predators.

3.6.2.3.2 Ground Sharks (Orders Carcharhiniformes), Mackerel Sharks (Order Lamniformes), Carpet Sharks (Order Orectolobiformes)

Ground Sharks and allies (bull, dusky, hammerheads, oceanic whitetip, and tiger) are cartilaginous fishes with two dorsal fins, an anal fin, five gill slits, and eyes with nictitating membranes. Reproduction includes internal fertilization with the young born fully developed. These sharks are highly migratory. They are found in the water column and bottom/seafloor habitats in the Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems and open ocean areas. These sharks are associated with hard and soft bottoms, nearshore and open ocean surface waters, and deep-sea habitats.

Mackerel Sharks and allies (great white, makos, and porbeagle) are cartilaginous fishes with a large first dorsal fin that is high, erect, and angular or somewhat rounded, anal fin with a keel, and a mouth extending behind the eyes. Reproduction includes internal fertilization with young being produced by means of eggs that are hatched within the body of the female. They are found in the water column and bottom/seafloor habitats in the West Greenland Shelf, Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems and open ocean areas. These sharks are associated with nearshore and open ocean surface water habitats.

Carpet Sharks and allies are a diverse group inhabiting coral and rocky reefs in the order Orectolobiformes. This group includes whale sharks which are the largest shark in the group and are one of three filter feeding sharks. Many of the carpet sharks, such as whale shark are also highly migratory. Carpet sharks all share certain characteristics, including their mouth being completely in front of eyes, both dorsal fins without spines, five pairs of gill slits, and an anal fin being present. Nurse sharks are also in this group and are usually yellowish-tan to dark brown, average around 8 to 9 ft. long, and can weigh over 200 pounds (lb.). They are nocturnal, scouting the sea bottom for prey such as crustaceans, molluscs and stingrays. They spend most of the day resting on sandy bottom or in caves or reef crevices. Whale sharks are another member of the carpet sharks group and are the largest shark in the world, growing to a length of over 40 ft.

3.6.2.3.3 Frilled and Cow Sharks (Order Hexanchiformes), Sawsharks (Order Pristiophoriformes), Dogfish Sharks (Order Squaliformes), and Angel Sharks (Order Squatiniformes)

Frill and cow sharks (sevengill, sixgill) are cartilaginous fishes, generally characterized by lacking traits such as an anal fin, and nictitating membrane; they do possess six to seven gill slits, compared to five gill slits found in all other sharks. Reproduction includes internal fertilization with young being produced by means of eggs that are hatched within the body of the female. They are associated with deep-sea habitats in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016; Moyle & Cech, 2004).

Sawshark (Bahamas) is a cartilaginous fish characterized by two spineless dorsal fins, absent anal fin, and five to six gill openings. Reproduction includes internal fertilization with young emerging from eggs that are hatched within the body of the female. This species is associated with deep-sea habitats in the Southeast U.S. Continental Shelf and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016).

Dogfish Sharks are cartilaginous fishes with both dorsal fins spines, not grooved, caudal peduncle with a pair of lateral keels. Reproduction includes internal fertilization with young emerging from eggs that are hatched within the body of the female. They are associated with soft bottom and deep-sea habitats in the West Greenland Shelf, Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016; Moyle & Cech, 2004).

Angel sharks (Atlantic and sand) are cartilaginous fishes with flat, batoid-like body, two small spineless dorsal fins behind pelvic fins, and anal fin absent. Reproduction includes internal fertilization with young emerging from eggs that are hatched within the body of the female. They are associated with soft bottom habitat in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016; Moyle & Cech, 2004).

3.6.2.3.4 Stingrays (Order Myliobatiformes), Sawfishes (Order Pristiformes), Skates and Guitarfishes (Order Rajiformes), and Electric Rays (Order Torpediniformes)

Stingrays and allies (eagle ray, manta) are cartilaginous fishes, distinguished by flattened bodies, enlarged pectoral fins that are fused to the head and gill slits that are placed on their ventral surfaces. Reproduction includes internal fertilization with the young born fully developed. They are associated with reefs, nearshore open ocean, bottom habitat, seagrass beds, and deep sea water column habitat in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016; Moyle & Cech, 2004).

Sawfishes and allies inhabit inshore tropical areas in warm-temperate contiental waters and can be found in ocean waters out to 400 ft. in depth. They are also found and in muddy bays, estuaries, river mouths, off of large continental islands, and in fresh water in rivers or lakes (Compagno & Last, 1984). They can be found at or near the surface of the water column, but are usually bottom dwellers that rest in mud or sandy soft bottoms. They may occur over the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Compagno & Last, 1984).

Skates and guitarfishes are cartilaginous fishes, distinguished by flattened bodies, two reduced dorsal fins, and a reduced caudal fin. Reproduction includes internal fertilization and deposition of egg sacks. They are associated with soft bottom habitat in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems. Species in this group are associated with soft bottom habitat (Froese & Pauly, 2016; Moyle & Cech, 2004).

Electric rays are cartilaginous fishes, distinguished by flattened bodies, two well-developed dorsal fins and caudal fin. Two large kidney shaped organs in a disc on either side of the electric ray's head distinguish it from others, as these organs are able to produce strong electric shock at will (Madl & Yip, 2000). Reproduction includes internal fertilization with young being produced by means of eggs that are hatched within the body of the female. Two species, the Atlantic torpedo ray (*Torpedo nobiliana*) and lesser electric ray (*Narcine bancroftii*), occur in the Study Area. They are associated with soft bottom habitat in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016; Moyle & Cech, 2004).

3.6.2.3.5 Ratfishes (Order Chimaeriformes)

Ratfishes (chimera, rabbitfish, and ratfish) are cartilaginous fishes, with smooth skin largely covered by placoid scales, and their color can range from black to brownish gray. Reproduction includes internal fertilization and deposition of egg capsules. Fishes in this group are associated with soft bottom and deep-sea habitats in the West Greenland Shelf, Scotian Shelf, Newfoundland-Labrador Shelf, Northeast

U.S. Continental Shelf, Southeast U.S. Continental Shelf, and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016).

3.6.2.3.6 Sturgeons (Order Acipenseriformes)

Sturgeons (Atlantic, Gulf, and shortnose) are cartilaginous, long-lived, late-maturing fishes with a heterocercal tail, an elongated spindle-like body that is smooth-skinned, scaleless and armored with five lateral rows of bony plates. They are found in riverine, estuarine, and marine environments in the water column, bottom, and seafloor habitats in the Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems. Sturgeons historically had commercial and recreational fishery importance. They are broadcast spawners (females release eggs into the water where the eggs are fertilized by males) and fertilized eggs attach to bottom substrate until hatching. Juveniles and adults prey upon bottom invertebrates such as clams and fishes. Sturgeons have few known predators.

3.6.2.3.7 Gars (Order Lepisosteiformes)

Gars (alligator, longnose, shortnose, and Florida) are mostly cartilaginous fishes with a slender body encased in heavy ganoid scales plates, abbreviated heterocercal tail, and needle-like teeth. They are found in chiefly in riverine and estuarine waters and considered very rare in the marine environment. In the marine environment, they typically occur at the surface or in the water column in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems. Gars have some recreational game fishery importance. They are broadcast spawners and fertilized eggs attach to submerged aquatic vegetation until hatching. Juveniles prey upon plankton, invertebrates, and amphibians, while adults eat blue crabs, fishes, birds, reptiles, and small mammals. Gars are preyed upon by fishes as juveniles and alligators as adults.

3.6.2.3.8 Herrings (Order Clupeiformes)

Herring and allies (anchovies, herrings, sardines, and shad) are bony fishes with a silvery body with the lateral line and fin spines absent, and usually scutes along ventral profile. They are found only in the marine environment in the water column, and seafloor habitats in the West Greenland Shelf, Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf, Gulf of Mexico and Caribbean Large Marine Ecosystems. Herring, menhaden, sardine, and anchovy species are well-known as valuable targets of commercial fisheries. Herring account for a large portion of the total worldwide fish catch (Food and Agriculture Organization of the United Nations, 2005, 2009). Herrings and allies are broadcast spawners. They are known to form schools to help conserve energy and minimize predation (Brehmer et al., 2007) which may facilitate some level of communication during predator avoidance (Marras et al., 2012). They feed on decaying organic matter and plankton while swimming in the water column (Moyle & Cech, 2004). Herring and allies support marine food webs as a forage fish and preyed upon by fish, birds, and marine mammals.

3.6.2.3.9 Tarpons (Orders Elopiformes and Albuliformes)

Tarpons and allies (bonefishes, halosaurs, ladyfish, and machete) are bony fishes with the body encased in silvery scales, a large mouth, a single dorsal fin (most), and a somewhat tapered tail with fin spines absent. They are associated with riverine, estuarine and marine environments on the surface, water column, and seafloor/bottom habitats in the Newfoundland-Labrador Shelf (halosaurs only), Northeast and Southeast U.S. Continental Shelves, Gulf of Mexico, and Caribbean Large Marine Ecosystems. Tarpon and allies are important game species, but are not considered edible. Tarpons and allies are broadcast spawners. Fertilized eggs float in the water column until hatching into a leptocephalus larva (ribbon-like, with no resemblance to the adult). During the change from larvae to juvenile, the body shrinks in length. Juveniles prey upon plankton and marine invertebrates, while adults feed on mid-water fishes. Tarpon and allies are nocturnal ambush predators (Wainwright & Richard, 1995) who prey on bottom-dwelling invertebrates and small fishes. Tarpons and allies are preyed upon by larger fishes, birds, and marine mammals.

3.6.2.3.10 Eels (Orders Anguilliforms, Notacanthiformes, and Saccopharyngiformes)

Eels (conger, cutthroat, duckbill, false moray, morays, sawtooth, short-tailed, spiny, gulpers, and pelican eels) are bony fishes with a very elongate body, usually scaleless with pelvic fins, and without fin spines. They are associated with riverine, estuarine and marine environments in the water column, and seafloor/bottom habitats in the Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems. Eels and allies have little fishery importance. Some species are broadcast spawners, and fertilized eggs float in the water column until hatching into a leptocephalus larva. Juveniles prey upon plankton and marine invertebrates, while adults feed on small fishes. Depending on the species and its habitat, eels can be diurnal or nocturnal ambush predators and prey on bottom-dwelling invertebrates and small fishes. Eels are preyed upon mostly by larger fishes.

3.6.2.3.11 Salmonids (Order Salmoniformes)

Salmon and allies (Arctic char, Atlantic salmon, and Atlantic whitefish) are bony fishes with silvery bodies with an adipose fin present and exhibit anadromy. They are found in riverine, estuarine, and marine environment in the water column, and seafloor habitats in the West Greenland Newfoundland-Labrador Shelf, and Northeast U.S. Continental Shelf Large Marine Ecosystems. Atlantic salmon is listed as endangered in the Study Area, as described in Section 3.6.2.2.1 (Atlantic Salmon [*Salmo salar*]). Salmon have historic fishery importance. The native distribution of Salmoniformes is restricted to the cold waters of the Northern Hemisphere. Most salmon spawn in freshwater and live in the sea; they are among the most thoroughly studied and commercially valuable fish groups in the world. Juveniles prey upon insects, plankton, and small fishes while adults feed mainly on fishes. Salmon are preyed upon by sharks, birds, and marine mammals.

3.6.2.3.12 Argentines and Allies (Order Argentiniformes)

Argentines and allies (argentines, barreleyes, deep-sea smelts, slickheads, and tubeshoulders) are bony fishes with typically silvery, elongate bodies, adipose fin and extremely large mouths sometimes present, and pelvic fins and spines sometimes absent. They are found only in the marine environment in the water column, and seafloor habitats in the Newfoundland-Labrador Shelf, Northeast U.S. Continental Shelf, and Gulf of Mexico Large Marine Ecosystems. Argentines and allies have little fishery importance. Argentines and allies vary in their reproduction strategy. Some deep-sea species are capable of bioluminescence and release scents that may help to attract mates. Argentines are broadcast spawners and fertilized eggs float in the water column until hatching. Argentines and allies likely have few predators, but may be preyed upon by larger fishes.

3.6.2.3.13 Catfishes (Order Siluriformes)

Catfishes (sea catfishes) are bony fishes with barbels on head, spines on dorsal and pectoral fins, lack scale, with an adipose fin present. They are found in estuarine and marine environment on bottom and seafloor habitats in the Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems. These fishes do have recreational fishery importance. Catfishes prefer soft bottom habitats, and can tolerate salinities of wide ranges in the open ocean and nearshore fresh waters (Gulf

Coast Research Laboratory, 2016). Reproduction is external with males incubate eggs in their mouth. All ages of fishes eat benthic invertebrates. Predators are likely very limited (Moyle & Cech, 2004).

3.6.2.3.14 Bristlemouths and Allies (Order Stomiiformes)

Bristlemouths and allies (dragonfishes, fangjaws, hatchfishes, and lightfishes) are bony fishes with photophores and adipose fin present and chin barbels sometimes present. Bristlemouths and hatchetfishes are small in size and the most abundant fishes in many parts of the world's oceans. They are capable of eating large and small prey items and are known to engage in prey-related vertical migration patterns. Other species in this order prey largely on other fishes (Moyle & Cech, 2004).

3.6.2.3.15 Greeneyes and Allies (Order Aulopiformes)

Greeneyes and allies (barracudinas, daggertooth, lizardfishes, pearleyes, and waryfishes) are bony fishes with an upper protrusible jaw, an adipose fin and forked tail usually present with fin spines absent. Most greeneyes and allies are small (less than 50 cm) predators capable of devouring a wide range of species, including other fishes nearly their same size and pelagic invertebrates. Fishes in this order are preyed upon by salmon, tunas, and swordfishes. Reproduction is usually external, and includes the ability to change sex (Froese & Pauly, 2016).

3.6.2.3.16 Lanternfishes and Allies (Order Myctophiformes)

Lanternfishes and allies (headlight, lampfishes, and lancetfishes) are bony fishes that are usually small-sized, with an adipose fin, forked tail and photophores usually present. Lanternfishes can occur closer to the surface at night (10 to 100 m) and deeper during the day (300 to 1200 m) (Froese & Pauly, 2016), where they may become prey for marine mammals. These fishes often are an important part of the deep scattering layer (Moyle & Cech, 2004). Lanternfishes prey upon copepods and krill (Van Noord et al., 2016).

3.6.2.3.17 Hakes and Allies (Order Gadiformes).

Hakes and allies (cods, codlings, grenadiers, and whiptails) are bony fishes with long dorsal and anal fins, no true spines in fins, although spinous rays present in dorsal fin of most species, and chin barbels are often present. Hakes and allies account for approximately half of the global commercial landings (Food and Agriculture Organization of the United Nations, 2005). Prey items for fishes in this group include small crustaceans during juvenile phases and larger crustaceans, squid, and fishes as adults. Predators include striped bass, sharks, and cetaceans (Froese & Pauly, 2016).

3.6.2.3.18 Brotulas and Allies (Order Ophidiiformes)

Brotulas and allies (cusk-eels) are bony fishes with pelvic absent or far forward and filamentous, dorsal and anal fins joined to caudal fin, and spines absent. These fishes exhibit a variety of reproductive strategies including external fertilization and giving live birth. Prey items for fishes in this group include small crustaceans during juvenile phases and larger crustaceans, squid and fishes as adults. Predators include striped bass, sharks, and cetaceans (Froese & Pauly, 2016).

3.6.2.3.19 Toadfishes and Allies (Order Batrachoidiformes)

Toadfishes and allies (midshipman) are bony fishes with compressed bodies, large, depressed head and mouth usually with tentacles, and two dorsal fins with the first with spines. These fishes are known to build nests (Moyle & Cech, 2004).

3.6.2.3.20 Anglerfishes and Allies (Order Lophiiformes)

Anglerfishes and allies (footballfishes, frogfishes, goosefishes, and sea devils) are bony fishes with globulose bodies, a spine on the first dorsal fin and the pelvic fins usually absent. Anglerfish attract potential prey using their first dorsal fin (illicium) as a lure (Yasugi & Hori, 2016). Fishes in these orders are found occasionally on the surface, but most frequently in the water column and seafloor habitats in the West Greenland Shelf, Newfoundland-Labrador Shelf, Scotian Shelf Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems. Additional adaptations include large mouths, sharp teeth, and sensitive lateral line [sensory] systems (Haedrich, 1996; Koslow, 1996; Marshall, 1996; Rex & Etter, 1998; Warrant & Locket, 2004). These fishes are mostly generalist feeders. Reproduction is not well studied, but sexes are separate and some exhibit parasitism (Moyle & Cech, 2004). Fishes in this group generally have no fishery importance.

3.6.2.3.21 Flying Fishes (Order Beloniformes)

Flying fishes (halfbeaks, needlefishes, and sauries) are bony fishes with jaws extended into a beak; pelvic fins very large wing-like; spines absent. These fishes are associated with reefs, submerged aquatic vegetation, and open ocean habitat in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems and open ocean areas (Froese & Pauly, 2016).

3.6.2.3.22 Killifishes (Order Cyprinodontiformes)

Killifishes (goldspotted, rivulus, and sheepshead minnows) are bony fishes with a protrusible upper jaw, fin spines rarely present, and a single dorsal fin. Killifishes are found in the water column of rivers and estuaries in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico and Caribbean Sea Large Marine Ecosystems. The mangrove rivulus (*Kleptolebias marmoratus*) is a species of concern in the Study Area, as listed in Table 3.6-1.

3.6.2.3.23 Silversides (Order Atheriniformes).

Silversides (Atlantic, beach, inland, and rough) are bony fishes with a silvery stripe on their sides, high pectoral fins, a dorsal fin, and the pelvic fin has a spine. These fishes are found on the surface and in the water column in the Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico and Caribbean Sea Large Marine Ecosystems. The Key silverside (*Menidia conchorum*) is a species of concern in the Study Area, as listed in Table 3.6-1.

3.6.2.3.24 Opahs and Allies (Order Lampriformes)

Opahs and allies (crestfishes, oarfishes, ribbonfishes, tapertails, and tube-eyes) are bony fishes with an upper protrusible jaw, pelvic fins located forward on body, below, or just behind insertion of pectoral fins. Toadfishes (midshipman) have compressed bodies, large, depressed head and mouth usually with tentacles, and two dorsal fins with the first with spines. These fishes are found in the water column and seafloor habitats in the Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems and open ocean areas. Fishes in this group exhibit a variety of reproductive strategies including external fertilization and parasitism. Prey items for fishes in this group include crustaceans, squid, and fishes.

3.6.2.3.25 Squirrelfishes and Allies (Order Beryciformes)

Squirrelfishes and allies (bigscales, fangtooths, pricklefishes, slimeheads, and whalefishes) are bony fishes with round bodies, one dorsal fin often set far back, with pelvic fins absent, and fin spines often present. Squirrelfishes (family Holocentridae) are the largest and most widely distributed family in the order, with over 60 species found throughout tropical and subtropical marine habitats (Moyle & Cech, 2004). Most species in this group occupy shallow nearshore reef and rocky areas where they hide during the day and come out at night to feed on zooplankton in the water column.

3.6.2.3.26 Dories and Allies (Order Zeiformes)

Dories and allies (boarfishes, oreos, and tinselfishes) are bony fishes that have deeply compressed bodies, protrusible jaws, spines in dorsal fin, and pelvic fin spines sometimes present. There are seven species recorded in the Study Area (Froese & Pauly, 2016). These fishes are only found in marine habitats and most of are deep sea species. Fishes in this order typically have large heads with distensible jaws that allow them to capture larger-sized prey, including fishes and crustaceans.

3.6.2.3.27 Pipefishes and Allies (Order Syngnathiformes)

Pipefishes and allies (cornetfish, seahorses, and snipefishes) are bony fishes, which exhibit unique body shapes with snout tube-like, mouth small, and scales often modified bony plates. These fishes are associated with hard and soft bottom, submerged aquatic vegetation, reefs, and deep-sea habitats in the West Greenland, Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016; Paxton & Eshmeyer, 1998). Some pipefishes and allies exhibit a high level of parental care by, brooding pouches (male seahorses), which results in relatively few young being produced (Helfman et al., 2009). Most fishes in this group are diurnal ambush predators and prey on zooplankton, marine invertebrates, and small fishes. Pipefishes and allies are preyed upon by larger fishes, and birds.

3.6.2.3.28 Sticklebacks (Order Gasterosteiformes)

Sticklebacks are small fishes comprised of only seven species that live in freshwater, saltwater, or brackish water (Helfman et al., 2009; Moyle & Cech, 2004). Species in this group are easily recognized by the presence of three to 16 isolated spines on their back in front of the dorsal fin, large eyes, and small upturned mouths. Most species in this group possess a row of bony plates on each side. Some sticklebacks display parental care through nest building. Fishes in this group are found in littoral marine waters and freshwater habitats in the Study Area.

3.6.2.3.29 Scorpionfishes (Order Scorpaeniformes)

Scorpionfishes and allies (poachers, sea robins, snailfishes, and sculpins) are bony fishes with usually strong spines on head and dorsal fin, cheeks with bony struts, and rounded pectoral fins. These fishes are associated with hard and soft bottom, reefs, and deep-sea habitats in the West Greenland, Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems and open ocean areas (Froese & Pauly, 2016; Paxton & Eshmeyer, 1998). Some scorpionfishes have commercial and recreation fishery importance (Moyle & Cech, 2004). Reproduction methods vary widely between species and include external fertilization and egg deposition (sculpins). Most fishes in this group are diurnal ambush predators and prey on bottom-dwelling invertebrates and small fishes. Scorpionfishes are allies are preyed upon by larger fishes, birds, and marine mammals.

3.6.2.3.30 Mullets (Order Mugiliformes)

Mullets (striped, white, fantail, mountain) are bony fishes with a streamline body, forked tail, hard angled mouth, large scales, high pectoral fins, and pelvic fins with one spine. Striped mullet is an important commercial fishery (Froese & Pauly, 2016). These fishes are associated with soft bottom, reefs, and nearshore open ocean habitats in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016; Moyle & Cech, 2004). Mullets are catadromous; they spawn in saltwater but spend most of their lives in freshwater environments.

3.6.2.3.31 Order Perciformes

The Perciformes, with over 7,800 species, is the largest order of vertebrates. They are extremely diverse, but most species are adapted for life as predators in the shallow or surface waters of the ocean. Some of the characteristics include fin spines present, dorsal fins either double or made up of two distinct parts with the lead spiny, adipose fin absent, pelvic fins thoracic or jugular in position or absent, pectoral fins on side of body; ctenoid scales, and closed swim bladder. Nearly half of all species belong to four families: gobies, wrasses seabasses, or blennies (Moyle & Cech, 2004). Fish groupings in this section generally follow the classification in Nelson (2016).

3.6.2.3.31.1 Perches and Allies

Perches and allies (angelfishes, cardinal fishes, damselfishes, drums, grunts, jacks, remoras, groupers, sea basses, snappers, and striped bass) are bony fishes with deep to moderately elongate bodies, one to two dorsal fins, with large mouth and eyes and thoracic pelvic fins. These fishes are associated with hard and soft bottom, reefs, submerged aquatic vegetation, open ocean, and deep-sea habitats in the Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems and open ocean areas (Froese & Pauly, 2016; Moyle & Cech, 2004).

3.6.2.3.31.2 Wrasses and Allies

Wrasses and allies (hogfishes, parrotfishes, wrasses, and damselfishes) are bony fishes with a compressed body, large scales, well-developed teeth, usually colorful coloring. Some wrasses and allies have recreational fishery and aquarium trade importance. Most of these fishes are associated with depths less than 30 m hard and soft bottom and reef habitats in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico and Caribbean Large Marine Ecosystems (Froese & Pauly, 2016; Moyle & Cech, 2004). Wrasses and allies can change sex, usually female-to-male and exhibit broadcast spawning, where the fertilized eggs float in the water column or attach to substrate until hatching into larvae. Most are diurnal opportunistic predators (Wainwright & Richard, 1995). Prey items include zooplankton, invertebrates, and small fishes. Predators of wrasses and allies include larger fishes and marine mammals.

3.6.2.3.31.3 Eelpouts and Allies

Eelpouts and allies (gunnels, ocean pout, pricklebacks, wolfeels) are bony fishes with an eel-like body, long dorsal and anal fins, and pelvic fins usually absent. These fishes are associated with soft bottom and deep-sea habitats in the West Greenland, Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016; Moyle & Cech, 2004). Eelpouts have been found to occur near deep-sea vents in the Atlantic Ocean's Mid-Atlantic Ridge (National Geographic, 2016).

3.6.2.3.31.4 Stargazers

Stargazers are bony fishes with an elongated body and eyes on top of their head and big oblique mouths. They are associated with soft bottom and deep-sea habitats in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016). This group of fishes ambush their prey from the sand.

3.6.2.3.31.5 Blennies, Gobies, and Allies

Blennies, gobies, and allies (barfin goby, freckled blenny, bridled goby, sleepers, and wormfishes) are bony fishes with an eel-like to sculpin-like body, pelvic fins reduced or fused. They are associated with hard and soft bottoms, reefs, and deep-sea habitats in the Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Caribbean Sea, and Gulf of Mexico Large Marine Ecosystems (Froese & Pauly, 2016).

3.6.2.3.31.6 Surgeonfishes

Surgeonfishes (doctorfish, Gulf surgeonfish, blue tang,) are bony fishes with bodies that are deeply compressed laterally, small mouth, small scales, and pelvic fins with spines. They are associated with reef habitats in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Caribbean Sea, and Gulf of Mexico Large Marine Ecosystems (Froese & Pauly, 2016). These fishes scrape algae from coral reefs with small, elongated mouths. These grazers provide an important function to the reef system by controlling the growth of algae on the reef (Goatley & Bellwood, 2009).

3.6.2.3.31.7 Tunas and Allies

Tuna and allies (barracudas, billfishes, swordfishes, and tunas) have a large mouth, keels usually present, pelvic fins often absent or reduced, and are fast swimmers. These fishes are associated with reefs, nearshore and offshore open ocean habitats in the Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico and Caribbean Large Marine Ecosystems (Froese & Pauly, 2016; Moyle & Cech, 2004). Most species have commercial and recreational importance. Tuna and allies are voracious open ocean predators (Estrada et al., 2003). They exhibit broadcast spawning and fertilized eggs float in the water column until hatching into larvae. Many feed nocturnally (Goatley & Bellwood, 2009) and in low-light conditions of twilight (Rickel & Genin, 2005). Many species in this group make large-scale migrations that allow for feeding in highly productive areas, which vary by season (Pitcher, 1995). Prey items include zooplankton for larvae and juvenile stages, while fishes and squid are consumed by subadults and adults. Predators of tuna and allies include other tuna species, billfishes, toothed whales, and some open ocean shark species. The Atlantic bluefin tuna is a NMFS Species of Concern that occurs in the Study Area, as presented in Table 3.6-1.

3.6.2.3.31.8 Butterfishes

Butterfishes (Ariommatids, driftfishes, and medusafishes) are bony fishes with a blunt and thick snout, teeth small, and a maxilla mostly covered by bone. They are associated with soft bottom and deep-sea habitats in the Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Froese & Pauly, 2016). Butterfishes form large schools over the continental shelf, except during winter months when it may descend to deeper waters. Juveniles are associated with jellies and floating vegetation. Adults feed mainly on jellies, squids, and crustaceans. Some species of butterfishes are also commercially harvested (Froese & Pauly, 2016).

3.6.2.3.32 Flatfishes (Order Pleuronectiformes)

Flatfishes (flounders, halibut, sand dabs, soles, and tonguefish) are bony fishes with a flattened body and eyes on one side of body (Table 3.6-2). These fishes occur on soft bottom habitat in inshore waters, as well as in deep-sea habitats in the West Greenland Shelf, Newfoundland-Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems and are an important part of commercial fisheries in the Study Area. The

Atlantic halibut (*Hippoglossus hippoglossus*) is a representative of this group and is also a Species of Concern. Flatfishes are broadcast spawners. They are ambush predators, and prey on other fishes and bottom-dwelling invertebrates. Some species in this group have been affected by overfishing (Drazen & Seibel, 2007; Froese & Pauly, 2010).

3.6.2.3.33 Pufferfishes (Order Tetraodontiformes)

Pufferfishes (boxfishes, filefishes, ocean sunfishes and triggerfishes) are bony fishes with thick or rough skin, sometimes with spines or scaly plates, pelvic fins absent or reduced, and a small mouth with strong teeth coalesced into a biting plate. They are associated with hard and soft bottom, reef, submerged aquatic vegetation, nearshore and offshore open-ocean, and deep-sea habitats in the Newfoundland-Labrador shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Southeast U.S. Continental Shelf, Caribbean Sea, and Gulf of Mexico Large Marine Ecosystems. Pufferfishes are broadcast spawners. Predators vary by species, but due to spiny and rough exterior of this group, it is likely few are successful. Prey vary by species, but includes jellies, crustaceans, detritus, molluscs, and other bottom dwelling marine invertebrates (Froese & Pauly, 2016).

3.6.3 Environmental Consequences

This section evaluates how, and to what degree, the activities described in Chapter 2 (Description of Proposed Action and Alternatives) potentially impact fishes known to occur within the Study Area. Tables 2.6-1 through 2.6-4 present the proposed typical training and testing activity locations for each alternative (including number of events). General characteristics of all U.S. Department of the Navy (Navy) stressors were introduced in Section 3.0.3.3 (Identifying Stressors for Analysis), and living resources' general susceptibilities to stressors were introduced in Section 3.0.3.6 (Biological Resource Methods). The stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors analyzed for fishes are:

- **Acoustic** (sonar and other transducers; air guns; pile driving; vessel noise; aircraft noise; and weapons noise)
- **Explosives** (in-air explosions and in-water explosions)
- **Energy** (in-water electromagnetic devices; in-air electromagnetic devices; high-energy lasers)
- **Physical disturbance and strikes** (vessels and in-water devices; aircraft and aerial targets, military expended materials, seafloor devices, pile driving)
- **Entanglement** (wires and cables, decelerators/parachutes, biodegradable polymers)
- **Ingestion** (military expended materials – munitions, military expended materials other than munitions)
- **Secondary stressors** (impacts to habitat and prey availability)

The analysis focuses on the fish groups and ESA-listed fish species discussed in Section 3.6.2 (Affected Environment). Largetooth sawfish, defined in Table 3.6-1 as extirpated, are not carried forward in the analysis as this species is unlikely to occur in the Study Area, and there would be no effect from training and testing activities. The analysis includes consideration of the mitigation that the Navy will implement to avoid potential impacts on fishes from explosives and the incidental benefit on fishes from the mitigation that the Navy will implement to avoid potential impacts on seafloor resources from explosives, and physical disturbance and strikes.

3.6.3.1 Acoustic Stressors

The following section analyzes potential impacts on fishes from proposed activities that involve acoustic stressors (i.e., sonar and other transducers; air guns; pile driving; vessel noise; aircraft noise; and weapons noise). It follows the outline and methodology for assessing potential impacts put forth in Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

3.6.3.1.1 Background

Effects of human-generated sound on fishes have been examined in numerous publications (Hastings & Popper, 2005; Hawkins et al., 2015; Mann, 2016; National Research Council, 1994, 2003; Neenan et al., 2016; Popper et al., 2004; Popper, 2003, 2008; Popper & Hastings, 2009b; Popper et al., 2014; Popper et al., 2016). The potential impacts from Navy activities are based on the analysis of available literature related to each type of effect. In addition, a Working Group organized under the American National Standards Institute-Accredited Standards Committee S3, Subcommittee 1, Animal Bioacoustics, developed sound exposure guidelines for fish and sea turtles (Popper et al., 2014), hereafter referred to as the *ANSI Sound Exposure Guideline* technical report. Where applicable, thresholds and relative risk factors presented in the *ANSI Sound Exposure Guideline* technical report were used to assist in the analysis of effects to fishes from Navy activities.

There are limited studies of fish responses to aircraft and weapons noise. For the purposes of this analysis, studies of the effects from sonar or vessel noise are used to inform fish responses to other continuous sources such as aircraft noise. Studies of the effects from impulsive sources (i.e., air guns and pile driving) are used to inform fish responses to other impulsive sources such as weapons noise. Where data from sonar and vessel noise exposures are limited, other continuous sounds such as white noise is used as a proxy to better understand potential reactions from fish. The following section discusses available information for non-explosive acoustic sources. Information on potential impacts from explosive sources is described under Section 3.6.3.2 (Explosive Stressors) where it differs from other impulsive sources described below.

3.6.3.1.1.1 Injury

Injury refers to the direct effects on the tissues or organs of a fish. Research on injury in fish caused by exposure to high-intensity or long-duration sound from air guns, impact pile driving and some sonars is discussed below. Moderate- to low-level noise from vessels, aircraft, and weapons use is described in Section 3.0.3.3.1 (Acoustic Stressors) and lacks the amplitude and energy to cause any direct injury. Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on injury and the framework used to analyze this potential impact.

Injury due to Impulsive Sound Sources

Impulsive sounds, such as those produced by seismic air guns and impact pile driving, may cause injury or mortality in fishes. Mortality and potential damage to the cells of the lateral line have been observed in fish larvae, fry, and embryos after exposure to single shots from a seismic air gun within close proximity to the sound source (0.1 to 6 m) (Booman et al., 1996; Cox et al., 2012). However, exposure of adult fish to a single shot from an air gun array (four air guns) within similar ranges (6 m), has not resulted in any signs of mortality within seven days after exposure (Popper et al., 2016). Although injuries occurred in adult fishes, they were similar to injuries seen in control subjects (i.e., fishes that were not exposed to the air gun) so there is little evidence that the air gun exposure solely contributed to the observed effects.

Injuries, such as ruptured swim bladders, hematomas, and hemorrhaging of other gas-filled organs, have been reported in fish exposed to a large number of simulated impact pile driving strikes with cumulative sound exposure levels up to 219 decibels referenced to 1 micropascal squared seconds (dB re 1 μPa^2-s) under highly controlled settings where fish were unable to avoid the source (Casper et al., 2012b; Casper et al., 2013a; Casper et al., 2013b; Halvorsen et al., 2011; Halvorsen et al., 2012a; Halvorsen et al., 2012b). However, it is important to note that these studies exposed fish to 900 or more strikes as the studies goal was largely to evaluate the equal energy hypothesis, which suggests that the effects of a large single pulse of energy is equivalent to the effects of energy received from many smaller pulses (as discussed in Smith & Gilley, 2008). Halvorsen (2011) and Casper et al. (2017) found that the equal energy hypothesis does not apply to effects of pile driving; rather, metrics relevant to injury could include, but not be limited to, cumulative sound exposure level, single strike sound exposure level, and number of strikes (Halvorsen et al., 2011). Furthermore, Casper et al. (2017) found the amount of energy in each pile strike and the number of strikes determines the severity of the exposure and the injuries that may be observed. For example, hybrid striped bass (white bass *Morone chrysops* x striped bass *Morone saxaltilis*) exposed to fewer strikes with higher single strike sound exposure values resulted in a higher number of, and more severe, injuries than bass exposed to an equivalent cumulative sound exposure level that contained more strikes with lower single strike sound exposure values. This is important to consider when comparing data from pile driving studies to potential effects from other impulsive sources (such as an explosion). Although single strike peak sound pressure levels were measured during these experiments (at average levels of 207 dB re 1 μPa), the injuries were only observed during exposures to multiple strikes; therefore, it is anticipated that a peak value much higher than those measured in these studies would be required to lead to injury.

These studies included species both with and without swim bladders. The majority of fish that exhibited injuries were those with swim bladders. Lake sturgeon (*Acipenser fulyescens*), a physostomous fish, was found to be less susceptible to injury from impulsive sources than Nile tilapia (*Oreochromis niloticus*) or hybrid striped bass, physoclistous fishes (Casper et al., 2017; Halvorsen et al., 2012a). As reported by Halvorsen et al. (2012a), the difference in results is likely due to the type of swim bladder in each fish. Physostomous fishes have an open duct connecting the swim bladder to their esophagus and may be able to quickly adjust the amount of gas in their body by gulping or releasing air. Physoclistous fishes do not have this duct and instead, gas pressure in the swim bladder is regulated by special tissues or glands. There were no mortalities reported during these experiments and in the studies where recovery was observed, the majority of exposure related injuries healed within a few days in a laboratory setting. In many of these controlled studies, neutral buoyancy was determined in the fishes prior to exposure to the simulated pile driving. However, fishes with similar physiology to those described in these studies that are exposed to actual pile driving activities may show varying levels of injury depending on their state of buoyancy.

Debusschere et al. (2014) largely confirmed the results discussed in the paragraph above with caged juvenile European sea bass (*Dicentrarchus labrax*) exposed to actual pile driving operations. No differences in mortality were found between control and experimental groups at similar levels tested in the experiments described in the paragraph above (sound exposure levels up to 215–222 dB re 1 μPa^2-s) and many of the same types of injuries occurred. Fishes with injuries from impulsive sources such as these may not survive in the wild due to harsher conditions and risk of predation.

Other potential effects from exposure to impulsive sound sources include potential bubble formation and neurotrauma. It is speculated that high sound pressure levels may also cause bubbles to form from micronuclei in the blood stream or other tissues of animals, possibly causing embolism damage (Hastings & Popper, 2005). Fishes have small capillaries where these bubbles could be caught and lead to the rupturing of the capillaries and internal bleeding. It has also been speculated that this phenomena could take place in the eyes of fish due to potentially high gas saturation within the eye tissues (Popper & Hastings, 2009b). Additional research is necessary to verify if these speculations apply to exposures to non-impulsive sources such as sonars. These phenomena have not been well studied in fishes and are difficult to recreate under real-world conditions.

As summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), exposure to high intensity and long duration impact pile driving or air gun shots did not cause mortality, and fishes typically recovered from injuries in controlled laboratory settings. Species tested to date can be used as viable surrogates for investigating injury in other species exposed to similar sources (Popper et al., 2014).

Injury due to Sonar and Other Transducers

Non-impulsive sound sources (e.g., sonar, acoustic modems, and sonobuoys) have not been known to cause direct injury or mortality to fish under conditions that would be found in the wild (Halvorsen et al., 2012a; Kane et al., 2010; Popper et al., 2007). Potential direct injuries (e.g., barotrauma, hemorrhage or rupture of organs or tissue) from non-impulsive sound sources, such as sonar, are unlikely because of slow rise times[1], lack of a strong shock wave such as that associated with an explosive, and relatively low peak pressures. General categories and characteristics of Navy sonar systems are described in Section 3.0.3.3.1.1 (Sonar and Other Transducers).

The effects of mid-frequency sonar-like signals (1.5–6.5 kHz) on larval and juvenile Atlantic herring (*Clupea harengus*), Atlantic cod (*Gadus morhura*), saithe (*Pollachius virens*), and spotted wolffish (*Anarhichas minor*) were examined by Jørgensen et al. (2005). Researchers investigated potential effects on survival, development, and behavior in this study. Among fish kept in tanks and observed for one to four weeks after sound exposure, no significant differences in mortality or growth-related parameters between exposed and unexposed groups were observed. Examination of organs and tissues from selected herring experiments did not reveal obvious differences between unexposed and exposed groups. However, two (out of 42) of the herring groups exposed to sound pressure levels of 189 dB re 1 µPa and 179 dB re 1 µPa had a post-exposure mortality of 19 and 30 percent, respectively. It is not clear if this increased mortality was due to the received level or to other unknown factors, such as exposure to the resonance frequency of the swim bladder. Jørgensen et al. (2005) estimated a resonant frequency of 1.8 kHz for herring and saithe ranging in size from 6.3 to 7.0 cm, respectively, which lies within the range of frequencies used during sound exposures and therefore may explain some of the noted mortalities.

Individual juvenile fish with a swim bladder resonance in the frequency range of the operational sonars may be more susceptible to injury or mortality. Past research has demonstrated that fish species, size and depth influences resonant frequency (Løvik & Hovem, 1979; McCartney & Stubbs, 1971). At resonance, the swim bladder, which can amplify vibrations that reach the fishes hearing organs, may absorb much of the acoustic energy in the impinging sound wave. It is suspected that the resulting oscillations may cause mortality, harm the auditory organs or the swim bladder (Jørgensen et al., 2005; Kvadsheim & Sevaldsen, 2005). However, damage to the swim bladder and to tissues surrounding the swim bladder was not observed in fishes exposed to sonar at their presumed swim bladder resonant

[1] Rise time: the amount of time for a signal to change from static pressure (the ambient pressure without the added sound) to high pressure. Rise times for non-impulsive sound typically have relatively gradual increases in pressure where impulsive sound has near instantaneous rise to a high peak pressure. For more detail, see Appendix D (Acoustic and Explosives Concepts).

frequency (Jørgensen et al., 2005). The physiological effect of sonars on adult fish is expected to be less than for juvenile fish because adult fish are in a more robust stage of development, the swim bladder resonant frequencies would be lower than that of mid-frequency active sonar, and adult fish have more ability to move from an unpleasant stimulus (Kvadsheim & Sevaldsen, 2005). Lower frequencies (i.e., generally below 1 kHz) are expected to produce swim bladder resonance in adult fishes from about 10–100 cm (McCartney & Stubbs, 1971). Fish, especially larval and small juveniles, are more susceptible to injury from swim bladder resonance when exposed to continuous signals within the resonant frequency range.

Hastings (1995) found "acoustic stunning" (loss of consciousness) in blue gouramis (*Trichogaster trichopterus*), a freshwater species, following an 8-minute continuous exposure to a 150 Hz pure tone with a sound pressure level of 198 dB re 1 µPa. This species of fish has an air bubble in the mouth cavity directly adjacent to the animal's braincase that may have caused this injury. Hastings (1991; 1995) also found that goldfish (*Carassius auratus*), also a freshwater species, exposed to a 250 Hz continuous wave sound with peak pressures of 204 dB re 1 µPa for two hours, and blue gourami exposed to a 150 Hz continuous wave sound at a sound pressure level of 198 dB re 1 µPa for 0.5 hours did not survive. These studies are examples of the highest known levels tested on fish and for relatively long durations. Stunning and mortality due to exposure to non-impulsive sound exposure has not been observed in other studies.

Three freshwater species of fish, the rainbow trout (*Oncorhynchus mykiss*), channel catfish (*Ictalurus punctatus*), and the hybrid sunfish (*Lepomis* sp.), were exposed to both low- and mid-frequency sonar (Kane et al., 2010; Popper et al., 2007). Low-frequency exposures with received sound pressure levels of 193 dB re 1 µPa occurred for either 324 or 648 seconds. Mid-frequency exposures with received sound pressure levels of 210 dB re 1 µPa occurred for 15 seconds. No fish mortality resulted from either experiment and during necropsy after test exposures, both studies found that none of the subjects showed signs of tissue damage related to exposure (Kane et al., 2010; Popper et al., 2007).

As summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), although fishes have been injured and killed due to intense, long-duration non-impulsive sound exposures, fish exposed under more realistic conditions have shown no signs of injury. Those species tested to date can be used as viable surrogates for estimating injury in other species exposed to similar sources.

3.6.3.1.1.2 Hearing Loss

Researchers have examined the effects on hearing in fishes from sonar-like signals, tones, and different continuous noise sources; however, studies from impulsive sources are limited to air gun and impact pile driving exposures. Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on hearing loss and the framework used to analyze this potential impact.

Exposure to high-intensity sound can cause hearing loss, also known as a noise-induced threshold shift, or simply a threshold shift (Miller, 1974). A temporary threshold shift (TTS) is a temporary, recoverable loss of hearing sensitivity. A TTS may last several minutes to several weeks, and the duration may be related to the intensity of the sound source and the duration of the sound (including multiple exposures). A permanent threshold shift (PTS) is non-recoverable, results from the destruction of tissues within the auditory system, permanent loss of hair cells, or damage to auditory nerve fibers (Liberman, 2016), and can occur over a small range of frequencies related to the sound exposure. However, the sensory hair cells of the inner ear in fishes are regularly replaced over time when they are damaged, unlike in mammals where sensory hair cells loss is permanent (Lombarte et al., 1993; Popper et al., 2014; Smith et al., 2006). As a consequence, PTS has not been known to occur in fishes and any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al., 2005; Popper et al., 2014; Smith et al., 2006). Although available data for some terrestrial mammals have shown signs of nerve damage after severe threshold shifts (e.g., Kujawa & Liberman, 2009; Lin et al., 2011), it is not known if damage to auditory nerve fibers could also occur in fishes, and if so, whether fibers would recover during this process. As with TTS, 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.

Hearing Loss due to Impulsive Sound Sources

Popper et al. (2005) examined the effects of a seismic air gun array on a fish with a swim bladder that is involved in hearing, the lake chub (*Couesius plumbeus*), and two species that have a swim bladder that is not involved in hearing, the northern pike (*Esox lucius*) and the broad whitefish (*Coregonus nasus*), a salmonid. In this study, the lowest received cumulative sound exposure level (5 shots with a mean sound pressure level of 177 dB re 1 µPa) at which effects were noted was 186 dB re 1 µPa^2-s. The results showed temporary hearing loss for both lake chub and northern pike to both 5 and 20 air gun shots, but not for the broad whitefish. Hearing loss was approximately 20 to 25 dB at some frequencies for both species, and full recovery of hearing took place within 18 hours after sound exposure. Examination of the sensory surfaces of the ears after allotted recovery times (one hour for 5 shot exposures, and up to 18 hours for 20 shot exposures) showed no damage to sensory hair cells in any of the fish from these exposures (Song et al., 2008).

McCauley et al. (2003) and McCauley and Kent (2012) showed loss of a small percent of sensory hair cells in the inner ear of caged fish exposed to a towed air gun array simulating a passing seismic vessel. Pink snapper (*Pargus auratus*), a species that has a swim bladder that is not involved in hearing, were exposed to multiple air gun shots for up to 1.5 hours (McCauley et al., 2003) where the maximum received sound exposure levels exceeded 180 dB re 1 µPa^2-s. The loss of sensory hair cells continued to increase for up to at least 58 days post exposure to 2.7 percent of the total cells. Gold band snapper (*Pristipomoides multidens*) and sea perch (*Lutjanis kasmira*), both fishes with a swim bladder involved in hearing, were also exposed to a towed air gun array simulating a passing seismic vessel (McCauley & Kent, 2012). Although received levels for these exposures have not been published, hair cell damage increased as the range of the exposure (i.e., range to the source) decreased. Again, the amount of damage was considered small in each case (McCauley & Kent, 2012). It is not known if this hair cell loss would result in hearing loss since fish have tens or even hundreds of thousands of sensory hair cells in the inner ear and only a small portion were affected by the sound (Lombarte & Popper, 1994; Popper & Hoxter, 1984). The question remains as to why McCauley and Kent (2012) found damage to sensory hair cells while Popper et al. (Popper et al., 2005) did not; however, there are many differences between the studies, including species and the precise sound source characteristics.

Hastings et al. (2008) exposed a fish with a swim bladder that is involved in hearing, the pinecone soldierfish (*Myripristis murdjan*), and three species that have a swim bladder that is not involved in hearing, the blue green damselfish (*Chromis viridis*), the saber squirrelfish (*Sargocentron spiniferum*), and the bluestripe seaperch (*Lutjanus kasmira*), to an air gun array. Fish in cages were exposed to multiple air gun shots with a cumulative sound exposure level of 190 dB re 1 µPa^2-s. The authors found no hearing loss in any fish examined up to twelve hours after the exposures.

In an investigation of another impulsive source, Casper et al. (2013b) found that some fishes may actually be more susceptible to barotrauma (e.g., swim bladder ruptures, herniations, and hematomas) than hearing effects when exposed to simulated impact pile driving. Hybrid striped bass (white bass [*Morone chrysops*] x striped bass [*Morone saxatilis*]) and Mozambique tilapia (*Oreochromis mossambicus*), two species with a swim bladder not involved in hearing, were exposed to sound exposure levels between 213 and 216 dB re 1 µPa^2-s. The subjects exhibited barotrauma and although researchers began to observe signs of inner ear hair cell loss, these effects were small compared to the other non-auditory injuries incurred. Researchers speculated that injury might occur prior to signs of hearing loss or TTS. These sound exposure levels may present the lowest threshold at which hearing effects may begin to occur.

Overall, PTS has not been known to occur in fishes tested to date. Any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al., 2005; Popper et al., 2014; Smith et al., 2006). The lowest sound exposure level at which TTS has been observed in fishes with a swim bladder involved in hearing is 186 dB re 1 µPa^2-s. As reviewed in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), fishes without a swim bladder, or fishes with a swim bladder that is not involved in hearing, would be less susceptible to hearing loss (i.e., TTS) than fishes with swim bladders involved in hearing, even at higher levels and longer durations.

Hearing Loss due to Sonar and Other Transducers

Several studies have examined the effects of the sound exposures from low-frequency sonar on fish hearing (i.e., Halvorsen et al., 2013; Kane et al., 2010; Popper et al., 2007). Hearing was measured both immediately post-exposure and for up to several days thereafter (Halvorsen et al., 2013; Kane et al., 2010; Popper et al., 2007). Maximum received sound pressure levels were 193 dB re 1 µPa for 324 or 648 seconds (a cumulative sound exposure level of 218 or 220 dB re 1 µPa^2-s, respectively) at frequencies ranging from 170 to 320 Hz (Kane et al., 2010; Popper et al., 2007) and 195 dB re 1 µPa for 324 seconds (a cumulative sound exposure level of 215 dB re 1 µPa^2-s) in a follow-on study (Halvorsen et al., 2013). Two species with a swim bladder not involved in hearing, the largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*), showed no loss in hearing sensitivity from sound exposure immediately after the test or 24 hours later. Channel catfish, a fish with a swim bladder involved in hearing, and some specimens of rainbow trout, a fish with a swim bladder not involved in hearing, showed a threshold shift (up to 10 to 20 dB of hearing loss) immediately after exposure to the low-frequency sonar when compared to baseline and control animals. Small thresholds shifts were detected for up to 24 hours after the experiment in some channel catfish. Although some rainbow trout showed signs of hearing loss, another group showed no hearing loss. The different results between rainbow trout test groups are difficult to understand, but may be due to development or genetic differences in the various groups of fish. Catfish hearing returned to, or close to, normal within about 24 hours after exposure to low-frequency sonar. Examination of the inner ears of the fish during necropsy revealed no differences from the control groups in ciliary bundles or other features indicative of hearing loss. The maximum time fish were held post exposure before sacrifice was 96 hours (Kane et al., 2010).

The same investigators examined the potential effects of mid-frequency active sonar on fish hearing and the inner ear (Halvorsen et al., 2012c; Kane et al., 2010). The maximum received sound pressure level was 210 dB re 1 µPa at a frequency of 2.8 to 3.8 kHz for a total duration of 15 seconds (cumulative sound exposure level of 220 dB re 1 µPa^2-s). Out of the species tested (rainbow trout and channel catfish), only one test group of channel catfish showed any hearing loss after exposure to mid-frequency active sonar. The investigators tested catfish during two different seasons and found that the group tested in October experienced TTS, which recovered within 24 hours, but fish tested in December showed no effect. It was speculated that the difference in hearing loss between catfish groups might have been due to the difference in water temperature during the testing period or due to differences between the two stocks of fish (Halvorsen et al., 2012b). Any effects on hearing in channel catfish due to sound exposure appeared to be short term and non-permanent (Halvorsen et al., 2012a; Kane et al., 2010).

Some studies have suggested that there may be some loss of sensory hair cells due to high intensity sources, indicating a loss in hearing sensitivity; however, none of those studies concurrently investigated the subjects' actual hearing range after exposure to these sources. Enger (1981) found loss of ciliary bundles of the sensory cells in the inner ears of Atlantic cod following one to five hours of exposure to pure tone sounds between 50 and 400 Hz with a sound pressure level of 180 dB re 1 µPa. Hastings (1995) found auditory hair-cell damage in goldfish, a freshwater species with a swim bladder that is involved in hearing. Goldfish were exposed to 250 Hz and 500 Hz continuous tones with maximum peak sound pressure levels of 204 dB re 1 µPa and 197 dB re 1 µPa, respectively, for about two hours. Similarly, Hastings et al. (1996) demonstrated damage to some sensory hair cells in oscars (*Astronotus ocellatus*) observed one to four days following a one hour exposure to a pure tone at 300 Hz with a sound pressure level of 180 dB re 1 µPa but no damage to the lateral line was observed. Both studies found a relatively small percentage of total hair cell loss from hearing organs despite long duration exposures. Effects from long-duration noise exposure studies are generally informative; however, they are not necessarily a direct comparison to intermittent short-duration sounds generated during Navy activities involving sonar and other transducers.

As noted in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), some fish species with a swim bladder that is involved in hearing may be more susceptible to TTS from high intensity non-impulsive sound sources, such as sonar and other transducers, depending on the duration and frequency content of the exposure. Fishes with a swim bladder involved in hearing and fishes with high-frequency hearing may exhibit TTS from exposure to low- and mid-frequency sonar, specifically at cumulative sound exposure levels above 215 dB re 1 µPa^2-s. Fishes without a swim bladder and fishes with a swim bladder that is not involved in hearing would be unlikely to detect mid- or other higher-frequency sonars and would likely require a much higher sound exposure level to exhibit the same effect from exposure to low-frequency active sonar.

Hearing Loss due to Vessel Noise

Little data exist on the effects of vessel noise on hearing in fishes. However, TTS has been observed in fishes exposed to elevated background noise and other non-impulsive sources (e.g., white noise). Caged studies on pressure sensitive fishes (i.e., fishes with a swim bladder involved in hearing and those with high frequency hearing) show some hearing loss after several days or weeks of exposure to increased background sounds, although the hearing loss seems to recover (e.g., Scholik & Yan, 2002b; Smith et al., 2004a; Smith et al., 2006). Smith et al. (2004a; 2006) exposed goldfish, to noise with a sound pressure level of 170 dB re 1 µPa and found a clear relationship between the amount of hearing loss and the duration of exposure until maximum hearing loss occurred at about 24 hours of exposure. A 10-minute exposure resulted in 5 dB of TTS, whereas a three-week exposure resulted in a 28 dB TTS that took over two weeks to return to pre-exposure baseline levels (Smith et al., 2004a). Recovery times were not measured by investigators for shorter exposure durations. It is important to note that these exposures were continuous and subjects were unable to avoid the sound source for the duration of the experiment.

Scholik and Yan (2001) demonstrated TTS in fathead minnows (*Pimephales promelas*), another pressure sensitive species with similar hearing capabilities as the goldfish, after a 24-hour continuous exposure to white noise (0.3 to 2.0 kHz) at 142 dB re 1 µPa, that did not recover 14 days post-exposure. This is the longest threshold shift documented to have occurred in a fish species, with the actual duration of the threshold shift being unknown, but exceeding 14 days. However, the same authors found that the bluegill sunfish (*Lepomis macrochirus*), a species that primarily detects particle motion and lacks specializations for hearing, did not show statistically significant elevations in auditory thresholds when exposed to the same stimulus (Scholik & Yan, 2002a). This demonstrates that fishes with a swim bladder involved in hearing and those with high-frequency hearing may be more sensitive to hearing loss than fishes without a swim bladder or those with a swim bladder not involved in hearing. Studies such as these should be treated with caution in comparison to exposures in a natural environment, largely due to the confined nature of the controlled setting where fishes are unable to avoid the sound source (e.g., fishes are held stationary in a tub), and due to the long, continuous durations of the exposures themselves (sometimes days to weeks). Fishes that are exposed to vessel noise in their natural environment, even in areas with higher levels of vessel movement, would only be exposed for a short duration (seconds or minutes) as vessels are transient and pass by.

As summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), some fish species with a swim bladder that is involved in hearing may be more susceptible to TTS from long duration continuous noise, such as broadband[2] white noise, depending on the duration of the exposure (thresholds are proposed based on continuous exposure of 12 hours). However, it is not likely that TTS would occur in fishes with a swim bladder not involved in hearing or in fishes without a swim bladder.

3.6.3.1.1.3 Masking

Masking refers to the presence of a noise that interferes with a fish's ability to hear biologically important sounds including those produced by prey, predators, or other fishes. Masking occurs in all vertebrate groups and can effectively limit the distance over which an animal can communicate and detect biologically relevant sounds. Human-generated continuous sounds (e.g., some sonar, vessel noise and vibratory pile driving) have the potential to mask sounds that are biologically important to fishes. Researchers have studied masking in fishes using continuous masking noise but masking due to intermittent, short duty cycle sounds has not been studied. Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on masking and the framework used to analyze this potential impact.

Masking is likely to occur in most fishes due to varying levels of ambient or natural noise in the environment such as wave action, precipitation, or other animal vocalizations (Popper et al., 2014). Ambient noise during higher sea states in the ocean has resulted in elevated thresholds in several fish species (Chapman & Hawkins, 1973; Ramcharitar & Popper, 2004). Although the overall intensity or loudness of ambient or human-generated noise may result in masking effects in fishes, masking may be most problematic when human-generated signals or ambient noise levels overlap the frequencies of biologically important signals (Buerkle, 1968, 1969; Popper et al., 2014; Tavolga, 1974).

[2] A sound or signal that contains energy across multiple frequencies.

Wysocki and Ladich (2005) investigated the influence of continuous white noise exposure on the auditory sensitivity of two freshwater fish with notable hearing specializations for sound pressure detection, the goldfish and the lined Raphael catfish (*Platydoras costatus*), and a freshwater fish without notable specializations, the pumpkinseed sunfish (*Lepomis gibbosus*). For the goldfish and catfish, baseline thresholds were lower than masked thresholds. Continuous white noise with a sound pressure level of approximately 130 dB re 1 µPa at 1 m resulted in an elevated threshold of 23 to 44 dB within the subjects' region of best sensitivity between 500 and 1000 Hz. There was less evidence of masking in the sunfish during the same exposures with only a shift of 11 dB. Wysocki and Ladich (2005) suggest that ambient sound regimes may limit acoustic communication and orientation, especially in animals with notable hearing specializations for sound pressure detection.

Masking could lead to potential fitness costs depending on the severity of the reaction (Radford et al., 2014; Slabbekoorn et al., 2010). For example, masking could result in changes in predator-prey relationships potentially inhibiting a fish's ability to detect predators and therefore increase its risk of predation (Astrup, 1999; Mann et al., 1998; Simpson et al., 2015; Simpson et al., 2016). Masking may also limit the distance over which fish can communicate or detect important signals (Codarin et al., 2009; Ramcharitar et al., 2001; Ramcharitar et al., 2006a) including sounds emitted from a reef for navigating larvae (Higgs, 2005; Neenan et al., 2016). If the masking signal is brief (a few seconds or less), biologically important signals may still be detected resulting in little effect to the individual. If the signal is longer in duration (minutes or hours) or overlaps with important frequencies for a particular species, more severe consequences may occur such as the inability to attract a mate and reproduce. Holt and Johnston (2014) were the first to demonstrate the Lombard effect in one species of fish, a potentially compensatory behavior where an animal increases the source level of its vocalizations in response to elevated noise levels. The Lombard effect is currently understood to be a reflex which may be unnoticeable to the animal or may lead to increased energy expenditure during communication.

The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) highlights a lack of data that exist for masking by sonar but suggests that the narrow bandwidth and intermittent nature of most sonar signals would result in only a limited probability of any masking effects. In addition, most sonars (mid-, high-, and very high-frequency) are above the hearing range of most marine fish species, eliminating the possibility of masking for these species. In most cases, the probability of masking would further decrease with increasing distance from the sound source.

In addition, no data are available on masking by impulsive signals (e.g., impact pile driving and air guns) (Popper et al., 2014). Impulsive sounds are typically brief, lasting only fractions of a second, where masking could occur only during that brief duration of sound. Biological sounds can typically be detected between pulses within close distances to the source unless those biological sounds are similar to the masking noise, such as impulsive or drumming vocalizations made by some fishes (e.g., cod or haddock). Masking could also indirectly occur because of repetitive impulsive signals where the repetitive sounds and reverberations over distance may create a more continuous noise exposure.

Although there is evidence of masking as a result of exposure to vessel noise, the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) does not present numeric thresholds for this effect. Instead, relative risk factors are considered and it is assumed the probability of masking occurring is higher at near to moderate distances from the source (up to hundreds of meters) but decreases with increasing distance (Popper et al., 2014).

3.6.3.1.1.4 Physiological Stress

Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on physiological stress and the framework used to analyze this potential impact. A fish must first be able to detect a sound above its hearing threshold and above the ambient noise level before a physiological stress reaction can occur. The initial response to a stimulus is a rapid release of stress hormones into the circulatory system, which may cause other responses such as elevated heart rate and blood chemistry changes. Although an increase in background sound has been shown to cause stress in humans and animals, only a limited number of studies have measured biochemical responses by fishes to acoustic stress (e.g., Goetz et al., 2015; Madaro et al., 2015; Remage-Healey et al., 2006; Smith et al., 2004b; Wysocki et al., 2006; Wysocki et al., 2007) and the results have varied. Researchers have studied physiological stress in fishes using predator vocalizations, non-impulsive or continuous, and impulsive noise exposures.

A stress response that has been observed in fishes includes the production of cortisol (a stress hormone) when exposed to sounds such as boat noise, tones, or predator vocalizations. Nichols et al. (2015) found that giant kelpfish (*Heterostichus rostratus*) had increased levels of cortisol with increased sound level and intermittency of boat noise playbacks. Cod exposed to a short-duration upsweep (a tone that sweeps upward across multiple frequencies) across 100 to 1,000 Hz had increases in cortisol levels, which returned to normal within one hour post-exposure (Sierra-Flores et al., 2015). Remage-Healey et al. (2006) found elevated cortisol levels in Gulf toadfish (*Opsanus beta*) exposed to low-frequency bottlenose dolphin sounds. The researchers observed none of these effects in toadfish exposed to low-frequency snapping shrimp "pops."

A sudden increase in sound pressure level or an increase in overall background noise levels can increase hormone levels and alter other metabolic rates indicative of a stress response, such as increased ventilation and oxygen consumption (Pickering, 1981; Popper & Hastings, 2009a; Simpson et al., 2015; Simpson et al., 2016; Smith et al., 2004a, 2004b). Similarly, reef fish embryos exposed to boat noise have shown increases in heart rate, another indication of a physiological stress response (Jain-Schlaepfer et al., 2018). Although results have varied, it has been shown that chronic or long-term (days or weeks) exposures of continuous man-made sounds can lead to a reduction in embryo viability (Sierra-Flores et al., 2015) and slowed growth rates (Nedelec et al., 2015).

However not all species tested to date show these reactions. Smith et al. (2004b) found no increase in corticosteroid, a class of stress hormones, in goldfish exposed to a continuous, band-limited noise (0.1–10 kHz) with a sound pressure level of 170 dB re 1 µPa for one month. Wysocki et al. (2007) exposed rainbow trout to continuous band-limited noise with a sound pressure level of about 150 dB re 1 µPa for nine months with no observed stress effects. Growth rates and effects on the trout's immune systems were not significantly different from control animals held at a sound pressure level of 110 dB re 1 µPa.

Fishes may have physiological stress reactions to sounds that they can hear. Generally, stress responses are more likely to occur in the presence of potentially threatening sound sources, such as predator vocalizations, or during the sudden onset of impulsive signals rather than from non-impulsive or continuous sources such as vessel noise or sonar. Stress responses are typically brief (a few seconds to minutes) if the exposure is short or if fishes habituate or learn to tolerate the noise that is being presented. Exposure to chronic noise sources can lead to more severe impacts such as reduced growth rates, which may lead to reduced survivability for an individual. It is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

3.6.3.1.1.5 Behavioral Reactions

Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on behavioral reactions and the framework used to analyze this potential impact. Behavioral reactions in fishes have been observed due to a number of different types of sound sources. The majority of research has been performed using air guns (including large-scale seismic surveys), sonar, and vessel noise. Fewer observations have been made on behavioral reactions to impact pile driving noise; although fish are likely to show similar behavioral reactions to any impulsive noise within or outside the zone for hearing loss and injury.

As with masking, a fish must first be able to detect a sound above its hearing threshold and above the ambient noise level before a behavioral reaction can potentially occur. Most fishes can only detect low-frequency sounds with the exception of a few species that can detect some mid and high frequencies (above 1 kHz).

Studies of fishes have identified the following basic behavioral reactions to sound: alteration of natural behaviors (e.g., startle or alarm), and avoidance (LGL Ltd Environmental Research Associates et al., 2008; McCauley et al., 2000; Pearson et al., 1992). In the context of this FEIS/OEIS, and to remain consistent with available behavioral reaction literature, the terms “startle” and “alarm” and “response” or “reactions” will be used synonymously.

In addition, observed behavioral effects to fish could include disruption to or alteration of natural activities such as swimming, schooling, feeding, breeding, and migrating. Sudden changes in sound level can cause fish to dive, rise, or change swimming direction. However, there is evidence that some fish may habituate to repeated exposures or learn to tolerate noise that is not seemingly unthreatening (e.g., Bruintjes et al., 2016; Nedelec et al., 2016b; Radford et al., 2016).

Changes in sound intensity may be more important to a fishes’ behavior than the maximum sound level. Sounds that fluctuate in level or have intermittent pulse rates tend to elicit stronger responses from fish than even stronger sounds with a continuous level (Neo et al., 2014; Schwarz & Greer, 1984). Interpreting behavioral responses can be difficult due to species-specific behavioral tendencies, motivational state (e.g., feeding or mating), an individual’s previous experience, and whether or not the fish are able to avoid the source (e.g., caged versus free-swimming subjects). Results from caged studies may not provide a clear understanding of how free-swimming fishes may react to the same or similar sound exposures (Hawkins et al., 2015).

Behavioral Reactions due to Impulsive Sound Sources

It is assumed that most species would react similarly to impulsive sources (i.e., air guns and impact pile driving). These reactions include startle or alarm responses and increased swim speeds at the onset of impulsive sounds (Fewtrell & McCauley, 2012; Pearson et al., 1992; Roberts et al., 2016). Data on behavioral reactions in fishes exposed to impulsive sound sources is mostly limited to studies using caged fishes and the use of seismic air guns (Løkkeborg et al., 2012). Several species of rockfish (*Sebastes* species) in a caged environment exhibited startle or alarm reactions to seismic air gun pulses between peak-to-peak sound pressure levels of 180 dB re 1 µPa and 205 dB re 1 µPa (Pearson et al., 1992). More subtle behavioral changes were noted at lower sound pressure levels, including decreased swim speeds. At the presentation of the sound, some species of rockfish settled to the bottom of the experimental enclosure and reduced swim speed. Trevally (*Pseudocaranx dentex*) and pink snapper (*Pagrus auratus*) also exhibited alert responses as well as changes in swim depth, speed and schooling behaviors when exposed to air gun noise (Fewtrell & McCauley, 2012). Both trevally and pink snapper swam faster and closer to the bottom of the cage at the onset of the exposure. However, trevally swam in tightly cohesive groups at the bottom of the test cages while pink snapper exhibited much looser group cohesion. These behavioral responses were seen during sound exposure levels as low as 147 up to 161 dB re 1 μPa^2-s but habituation occurred in all cases, either within a few minutes or up to 30 minutes after the final air gun shot (Fewtrell & McCauley, 2012; Pearson et al., 1992).

Some studies have shown a lack of behavioral reactions to air gun noise. Herring exposed to an approaching air gun survey (from 27 to 2 km over 6 hours), resulting in single pulse sound exposure levels of 125 to 155 dB re 1 μPa^2-s, did not react by changing direction or swim speed (Pena et al., 2013). Although these levels are similar to those tested in other studies which exhibited responses (Fewtrell & McCauley, 2012), the distance of the exposure to the test enclosure, the slow onset of the sound source, and a strong motivation for feeding may have affected the observed response (Pena et al., 2013). In another study, Wardle et al. (2001) observed marine fish on an inshore reef before, during, and after an air gun survey at varying distances. The air guns were calibrated at a peak level of 210 dB re 1 µPa at 16 m and 195 dB re 1 µPa at 109 m from the source. Other than observed startle responses and small changes in position of pollack, when the air gun was located within close proximity to the test site (within 10 m), they found no substantial or permanent changes in the behavior of the fish on the reef throughout the course of the study. Behavioral responses to impulsive sources are more likely to occur within near and intermediate (tens to hundreds of meters) distances from the source as opposed to far distances (thousands of meters) (Popper et al., 2014).

Unlike the previous studies, Slotte et al. (2004) used fishing sonar (38 kHz echo sounder) to monitor behavior and depth of blue whiting (*Micromesistius poutassou*) and Norwegian spring herring (*Claupea harengus L.*) spawning schools exposed to air gun signals. They reported that fishes in the area of the air guns appeared to go to greater depths after the air gun exposure compared to their vertical position prior to the air gun usage. Moreover, the abundance of animals 30 to 50 km away from the air guns increased during seismic activity, suggesting that migrating fish left the zone of seismic activity and did not re-enter the area until the activity ceased. It is unlikely that either species was able to detect the fishing sonar, however, it should be noted that these behavior patterns may have also been influenced by other factors such as motivation for feeding, migration, or other environmental factors (e.g., temperature, salinity, etc.) (Slotte et al., 2004). In a similar study, overall abundance of multiple species of reef fish decreased at a site monitored with video cameras approximately 8 km away from a seismic survey. This decrease was noted in comparison to abundances monitored on three consecutive days prior to the start of the survey. Received levels of the air gun signals and monitoring of other areas surrounding the reef were not completed during this study so it is not known how loud the signals were on the reef, or whether fishes avoided the area completely or simply moved to a close by reef (Paxton et al., 2017).

Alterations in natural behavior patterns due to exposure to pile driving noise have not been studied as thoroughly, but reactions noted thus far are similar to those seen in response to seismic surveys. These changes in behavior include startle responses, changes in depth (in both caged and free-swimming subjects), increased swim speeds, changes in ventilation rates, directional avoidance, and changes in social behaviors such as shoaling and distance from neighboring fish (observed in caged fish) (e.g., Hawkins et al., 2014; Herbert-Read et al., 2017; Mueller-Blenkle et al., 2010; Neo et al., 2015; Roberts et al., 2016). The severity of response varied greatly by species and received sound pressure level of the exposure. For example, some minor behavioral reactions such as startle responses were observed during caged studies with a sound pressure level as low as 140 dB re 1 µPa (Neo et al., 2014). However, only some free-swimming fishes avoided pile driving noise at even higher sound pressure levels between 152 and 157 dB re 1 µPa (Iafrate et al., 2016). In addition, Roberts et al. (2016) observed that although multiple species of free swimming fish responded to simulated pile driving recordings, not all responded consistently and, in some cases, only one fish would respond while the others continued feeding from a baited remote underwater video. Other fish responded to different strikes. The repetition rate of pulses during an exposure may also have an effect on what behaviors were noted and how quickly these behaviors recovered as opposed to the overall sound pressure or exposure level. For example, Neo et al. (2014) observed slower recovery times in fishes exposed to intermittent sounds (similar to pile driving) compared to continuous exposures.

As summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), species may react differently to the same sound source depending on a number of variables, such as the animal's life stage or behavioral state (e.g., feeding, mating). Without specific data, it is assumed that fishes react similarly to all impulsive sounds outside the zone for hearing loss and injury. Observations of fish reactions to large-scale air gun surveys are informative, but not necessarily directly applicable to analyzing impacts from the short term, intermittent use of all impulsive sources. It is assumed that fish have a high probability of reacting to an impulsive sound source within near and intermediate distances (tens to hundreds of meters), and a decreasing probability of reaction at increasing distances (Popper et al., 2014).

Behavioral Reactions due to Sonar and Other Transducers

Behavioral reactions to sonar have been studied both in caged and free-living fish although results can oftentimes be difficult to interpret depending on the species tested and the study environment. Jørgensen et al. (2005) showed that caged cod and spotted wolf fish (*Anarhichas minor*) lacked any response to simulated sonar between 1 and 8 kHz. However, within the same study, reactions were seen in juvenile herring. It is likely that the sonar signals were inaudible to the cod and wolf fish (species that lack notable hearing specializations), but audible to herring which do possess hearing capabilities in the frequency ranges tested.

Doksæter et al. (2009; 2012) and Sivle et al. (2012; 2014) studied the reactions of both wild and captive Atlantic herring to the Royal Netherlands Navy's experimental mid-frequency active sonar ranging from 1 to 7 kHz. The behavior of the fish was monitored in each study either using upward looking echosounders (for wild herring) or audio and video monitoring systems (for captive herring). The source levels used within each study varied across all studies and exposures with a maximum received sound pressure level of 181 dB re 1 µPa and maximum cumulative sound exposure level of 184 dB re 1 $\mu Pa^2 \cdot s$. No avoidance or escape reactions were observed when herring were exposed to any sonar sources. Instead, significant reactions were noted at lower received sound levels of different non-sonar sound types. For example, dive responses (i.e., escape reactions) were observed when herring were exposed to killer whale feeding sounds at received sound pressure levels of approximately 150 dB re 1 µPa (Sivle et al., 2012). Startle responses were seen when the cages for captive herring were hit with a wooden stick and with the ignition of an outboard boat engine at a distance of 1 meter from the test pen (Doksaeter et al., 2012). It is possible that the herring were not disturbed by the sonar, were more motivated to continue other behaviors such as feeding, or did not associate the sound as a threatening stimulus. Based on these results (Doksaeter et al., 2009; Doksaeter et al., 2012; Sivle et al., 2012), Sivle et al.

(2014) created a model in order to report on the possible population-level effects on Atlantic herring from active naval sonar. The authors concluded that the use of naval sonar poses little risk to populations of herring regardless of season, even when the herring populations are aggregated and directly exposed to sonar.

There is evidence that elasmobranchs (cartilaginous fish including sharks and rays) also respond to human-generated sounds. Myrberg and colleagues did experiments in which they played back sounds (e.g., pulsed tones below 1 kHz) and attracted a number of different shark species to the sound source (e.g., Casper et al., 2012a; Myrberg et al., 1976; Myrberg et al., 1969; Myrberg et al., 1972; Nelson & Johnson, 1972). The results of these studies showed that sharks were attracted to irregularly pulsed low-frequency sounds (below several hundred Hz), in the same frequency range of sounds that might be produced by struggling prey. However, sharks are not known to be attracted to continuous signals or higher frequencies that they presumably cannot hear (Casper & Mann, 2006; Casper & Mann, 2009).

Only a few species of marine fishes can detect sonars above 1 kHz (see Section 3.6.2.1.3, Hearing and Vocalization) meaning that most fishes would not detect most mid-, high-, or very high-frequency Navy sonars. The few marine species that can detect above 1 kHz and have some hearing specializations may be able to better detect the sound and would therefore be more likely to react. However, researchers have found little reaction by adult fish in the wild to sonars within the animals' hearing range (Doksaeter et al., 2009; Doksaeter et al., 2012; Sivle et al., 2012). The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) suggests that fish able to hear sonars would have a low probability of reacting to the source within near or intermediate distances (within tens to hundreds of meters) and a decreasing probability of reacting at increasing distances.

Behavioral Reactions due to Vessel Noise

Vessel traffic also contributes to the amount of noise in the ocean and has the potential to affect fishes. Several studies have demonstrated and reviewed avoidance responses by fishes (e.g., herring and cod) to the low-frequency sounds of vessels (De Robertis & Handegard, 2013; Engås et al., 1995; Handegard et al., 2003). Misund (1997) found fish ahead of a ship that showed avoidance reactions did so at ranges of 50 to 150 m. When the vessel passed over them, some species of fish responded with sudden escape responses that included lateral avoidance or downward compression of the school.

As mentioned in Section 3.6.3.1.1.5 (Behavioral Reactions), behavioral reactions are quite variable depending on a number of factors such as (but not limited to) the type of fish, its life history stage, behavior, time of day, location, the type of vessel, and the sound propagation characteristics of the water column (Popper et al., 2014; Schwarz & Greer, 1984). Reactions to playbacks of continuous noise or passing vessels generally include basic startle and avoidance responses, as well as evidence of distraction and increased decision-making errors. Other specific examples of observed responses include; increased group cohesion, changes in vertical distribution in the water column, changes in swim speeds, as well as changes in feeding efficacy such as reduced foraging attempts and increased mistakes (i.e., lowered discrimination between food and non-food items) (Bracciali et al., 2012; De Robertis & Handegard, 2013; Handegard et al., 2015; Nedelec et al., 2015; Nedelec et al., 2017; e.g., Neo et al., 2015; Payne et al., 2015; Purser & Radford, 2011; Roberts et al., 2016; Sabet et al., 2016; Simpson et al., 2015; Simpson et al., 2016; Voellmy et al., 2014a; Voellmy et al., 2014b). As mentioned above, responses may also be dependent on the type of vessel fish are exposed to. For example, juvenile damselfish (*Pomacentrus wardi*) exposed to sound from a two stroke engine resulted in startle responses, reduction in boldness (increased time spent hiding, less time exhibiting exploratory behaviors), space use (maximum distance ventured from shelter), as well as more conservative reactions to visual stimuli analogous to a potential predator. However, damselfish exposed to sound from a four stroke engine generally displayed similar responses as control fish exposed to ambient noise (e.g., little or no change in boldness) (McCormick et al., 2018).

Changes in anti-predator response have also been observed but vary by species. During exposures to vessel noise, juvenile Ambon damselfish (*Pomacentrus amboinensis*) and European eels showed slower reaction times and lacked startle responses to predatory attacks which subsequently showed signs of distraction and increased their risk of predation during both simulated and actual predation experiments (Simpson et al., 2015; Simpson et al., 2016). Spiny chromis (*Acanthochromis polyacanthus*) exposed to chronic boat noise playbacks spent less time feeding and interacting with offspring, and increased defensive acts. In addition, offspring survival rates were also lower at nests exposed to chronic boat noise playbacks versus those exposed to ambient playbacks (Nedelec et al., 2017). This suggests that chronic or long term (up to 12 consecutive days) exposures could have more severe consequences than brief exposures.

In contrast, larval Atlantic cod showed a stronger anti-predator response and were more difficult to capture during simulated predator attacks (Nedelec et al., 2015). There are also observations of a general lack of response to shipping and pile driving playback noise by grey mullet (*Chelon labrosus*) and two-spotted gobys (*Gobiusculus flavescens*) (Roberts et al., 2016). Mensinger et al. (2018) found that Australian snapper (*Pagrus auratus*) located in a protected area showed no change in feeding behavior or avoidance during boat passes, whereas snapper in areas where fishing occurs startled and ceased feeding behaviors during boat presence. This supports that location and past experience also have an influence on whether fishes react.

Although behavioral responses such as those listed above were often noted during the onset of most sound presentations, most behaviors did not last long and animals quickly returned to baseline behavior patterns. In fact, in one study, when given the chance to move from a noisy tank (with sound pressure levels reaching 120–140 dB re 1 µPa) to a quieter tank (sound pressure levels of 110 dB re 1 µPa), there was no evidence of avoidance. The fish did not seem to prefer the quieter environment and continued to swim between the two tanks comparable to control sessions (Neo et al., 2015). However, many of these reactions are difficult to extrapolate to real world conditions due to the captive environment in which testing occurred.

Most fish species should be able to detect vessel noise due to its low-frequency content and their hearing capabilities (see Section 3.6.2.1.3, Hearing and Vocalization). The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) suggests that fishes have a high to moderate probability of reacting to nearby vessel noise (i.e., within tens of meters) with decreasing probability of reactions with increasing distance from the source (hundreds or more meters).

3.6.3.1.1.6 Long-Term Consequences

Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on potential pathways for long-term consequences. Mortality removes an individual fish from the population and injury reduces the fitness of an individual. Few studies have been conducted on any long-term consequences from repeated hearing loss, stress, or behavioral reactions in fishes due to exposure to loud sounds (Hawkins et al., 2014; Popper & Hastings, 2009a; Popper et al., 2014). Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with costs that can accumulate over time to cause long-term consequences for the individual. These long-term consequences may affect the survivability of the individual or if impacting enough individuals, may have population-level effects including: alteration from migration paths, avoidance of important habitat, or even cessation of foraging or reproductive behavior (Hawkins et al., 2014). Conversely, some animals habituate to or become tolerant of repeated exposures over time, learning to ignore a stimulus that in the past has not accompanied any overt threat. In fact, Sivle et al. (2016) predicted that exposures to sonar at the maximum levels tested would only result in short-term disturbance and would not likely affect the overall population in sensitive fishes such as herring.

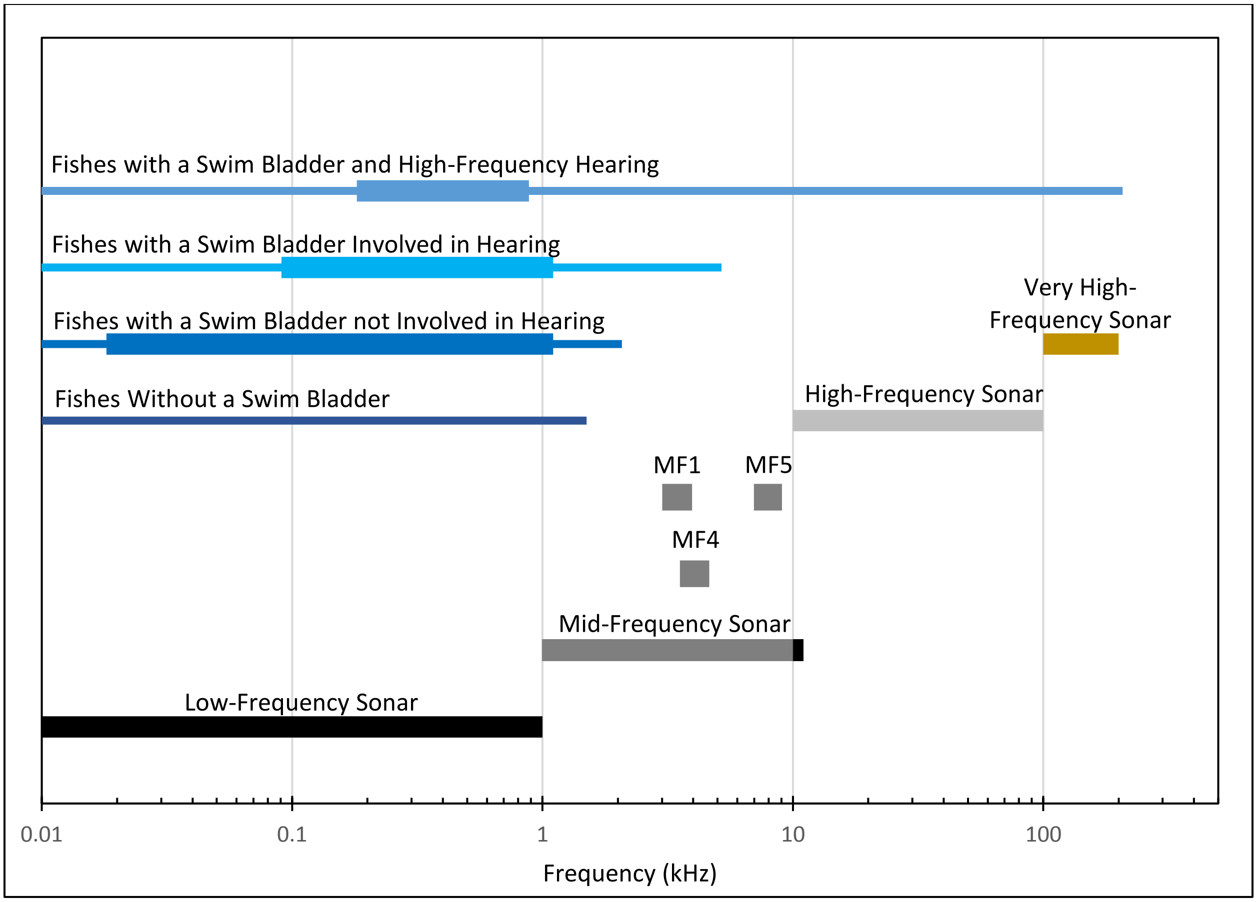
3.6.3.1.2 Impacts from Sonar and Other Transducers

Sonar and other transducers proposed for use are transient in most locations because activities that involve sonar and other transducers take place at different locations throughout the Study Area. A few activities involving sonar and other transducers occur in inshore waters (within bays and estuaries), including at pierside locations. Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories and characteristics of these systems and the number of hours these sonars will be operated are described in Section 3.0.3.3 (Identifying Stressors for Analysis). The activities analyzed in the EIS/OEIS that use sonar and other transducers are described in Appendix A (Navy Activity Descriptions).

As described under Section 3.6.3.1.1.1 (Injury – Injury due to Sonar and Other Transducers), direct injury from sonar and other transducers is highly unlikely because injury has not been documented in fish exposed to sonar (Halvorsen et al., 2012c; Halvorsen et al., 2013; Popper et al., 2007) and therefore is not considered further in this analysis.

Fishes are not equally sensitive to noise at all frequencies. Fishes must first be able to hear a sound in order to be affected by it. As discussed in Section 3.6.2.1.3 (Hearing and Vocalization), many marine fish species tested to date hear primarily below 1 kHz. For the purposes of this analysis, fish species were grouped into one of four fish hearing groups based on either their known hearing ranges (i.e., audiograms) or physiological features that may be linked to overall hearing capabilities (i.e., swim bladder with connection to, or in close proximity to, the inner ear). Figure 3.6-6 provides a summary of hearing threshold data from available literature (e.g., Casper & Mann, 2006; Deng et al., 2013; Kéver et al., 2014; Mann et al., 2001; Ramcharitar et al., 2006b) to demonstrate the maximum potential range of frequency detection for each hearing group.

Due to data limitations, these estimated hearing ranges may be overly conservative in that they may extend beyond what some species within a given fish hearing group may actually detect. For example, although most sharks are sensitive to lower frequencies, well below 1 kHz, the bull shark has been tested and can detect frequencies up to 1.5 kHz (Kritzler & Wood, 1961; Myrberg, 2001) and therefore represents the uppermost known limit of frequency detection for this hearing group. The upper bound of each fish hearing group's frequency range is outside of the range of best sensitivity for all fishes within that group. As a result, fishes within each group would only be able to detect those upper frequencies at close distances to the source, and from sources with relatively high source levels.



Notes: kHz: kilohertz; MF1: 3.5 kHz; MF4: 4 kHz; MF5: 8 kHz.

Thin blue lines represent the estimated minimum and maximum range of frequency detection for each group. All hearing groups are assumed to hear down to 0.01 kHz regardless of available data. Thicker portions of each blue line represent the estimated minimum and maximum range of best sensitivity for that group. Currently, no data are available to estimate the range of best sensitivity for fishes without a swim bladder. Although each sonar class is represented graphically by the horizontal black, grey and brown bars, not all sources within each class would operate at all the displayed frequencies. Example mid-frequency sources are provided to further demonstrate this.

Figure 3.6-6: Fish Hearing Group and Navy Sonar Frequency Ranges

Figure 3.6-6 is not intended as a composite audiogram, but rather displays the basic overlap in potential frequency content for each hearing group with Navy defined sonar classes (i.e., low-, mid-, high- and very high-frequency) as discussed under Section 3.0.3.3.1.1 (Sonar and Other Transducers – Classification of Sonar and Other Transducers).

Systems within the low-frequency sonar class present the greatest potential for overlap with fish hearing. Some mid-frequency sonars and other transducers may also overlap some species' hearing ranges, but to a lesser extent than low-frequency sonars. For example, the only hearing groups that have the potential to be able to detect mid-frequency sources within bins MF1, MF4 and MF5 are fishes with a swim bladder involved in hearing and with high-frequency hearing. It is anticipated that most marine fishes would not hear or be affected by mid-frequency Navy sonars or other transducers with operating frequencies greater than about 1–4 kHz. Only a few fish species (i.e., fish with a swim bladder and high-frequency hearing specializations) can detect and therefore be potentially affected by high- and very high-frequency sonars and other transducers.

The most probable impacts from exposure to sonar and other transducers are TTS (for more detail see Section 3.6.3.1.1.2, Hearing Loss), masking (for more detail see Section 3.6.3.1.1.3, Masking), physiological stress (for more detail see Section 3.6.3.1.1.4, Physiological Stress), and behavioral reactions (for more detail see Section 3.6.3.1.1.5, Behavioral Reactions). Analysis of these effects is provided below.

3.6.3.1.2.1 Methods for Analyzing Impacts from Sonar and Other Transducers

The Navy performed a quantitative analysis to estimate the range to TTS for fishes exposed to sonar and other transducers used during Navy training and testing activities. Inputs to the quantitative analysis included sound propagation modeling in the Navy's Acoustic Effects Model to the sound exposure criteria and thresholds presented below. Although range to effects are predicted, density data for fish species within the Study Area are not available; therefore, it is not possible to estimate the total number of individuals that may be affected by sound produced by sonar and other transducers.

Criteria and thresholds to estimate impacts from sonar and other transducers are presented below in Table 3.6-3. Thresholds for hearing loss are typically reported in cumulative sound exposure level so as to account for the duration of the exposure. Therefore, thresholds reported in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) that were presented in other metrics were converted to sound exposure level based on the signal duration reported in the original studies (see Halvorsen et al., 2012b; Halvorsen et al., 2013; Kane et al., 2010; Popper et al., 2007). General research findings from these studies can be reviewed in Section 3.6.3.1.1.2 (Hearing Loss).

Table 3.6-3: Sound Exposure Criteria for TTS from Sonar

Fish Hearing Group	*TTS from Low-Frequency Sonar (SEL_{cum})*	*TTS from Mid-Frequency Sonar (SEL_{cum})*
Fishes without a swim bladder	NC	NC
Fishes with a swim bladder not involved in hearing	> 210	NC
Fishes with a swim bladder involved in hearing	210	220
Fishes with a swim bladder and high-frequency hearing	210	220

Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), NC = effects from exposure to sonar is considered to be unlikely, therefore no criteria are reported, ">" indicates that the given effect would occur above the reported threshold.

For mid-frequency sonars, fishes with a swim bladder involved in hearing have shown signs of hearing loss because of mid-frequency sonar exposure at a maximum received sound pressure level of 210 dB re 1 μPa for a total duration of 15 seconds. To account for the total duration of the exposure, the threshold for TTS is a cumulative sound exposure level of 220 dB re 1 μPa^2-s (Halvorsen et al., 2012b; Kane et al., 2010). The same threshold is used for fishes with a swim bladder and high-frequency hearing as a conservative measure although fishes in this hearing group have not been tested for the same impact. TTS has not been observed in fishes with a swim bladder that is not involved in hearing exposed to mid-frequency sonar. Fishes within this hearing group do not sense pressure well and typically cannot hear at frequencies above 1 kHz (Halvorsen et al., 2012b; Popper et al., 2014). Therefore, no criteria were proposed for fishes with a swim bladder that is not involved in hearing from exposure to mid-frequency sonars as it is considered unlikely for TTS to occur. Fishes without a swim bladder are even less susceptible to noise exposure; therefore, TTS is unlikely to occur and no criteria are proposed for this group either.

For low-frequency sonar, as described in Section 3.6.3.1.1.2 (Hearing Loss), exposure of fishes with a swim bladder has resulted in TTS (Halvorsen et al., 2013; Kane et al., 2010; Popper et al., 2007). Specifically, fishes with a swim bladder not involved in hearing showed signs of hearing loss after exposure to a maximum received sound pressure level of 193 dB re 1 μPa for 324 and 648 seconds (cumulative sound exposure level of 218 and 220 dB re 1 μPa^2-s, respectively) (Kane et al., 2010; Popper et al., 2007). In addition, exposure of fishes with a swim bladder involved in hearing to low-frequency sonar at a sound pressure level of 195 dB re 1 μPa for 324 seconds (cumulative sound exposure level of 215 dB re 1 μPa^2-s) resulted in TTS (Halvorsen et al., 2013). Although the results were variable, it can be assumed that TTS may occur in fishes within the same hearing groups at similar exposure levels. As a conservative measure, the threshold for TTS from exposure to low-frequency sonar for all fish hearing groups with a swim bladder was rounded down to a cumulative sound exposure level of 210 dB re 1 μPa^2-s.

Criteria for high- and very high-frequency sonar were not available in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014); however, only species with a swim bladder involved in hearing and with high-frequency specializations such as shad could potentially be affected. The majority of fish species within the Study Area are unlikely to be able to detect these sounds. There is little data available on hearing loss from exposure of fishes to these high-frequency sonars. Due to the lack of available data, and as a conservative measure, effects to these hearing groups from high-frequency sonars would utilize the lowest threshold available for other hearing groups (a cumulative sound exposure level of 210 dB re 1 μPa^2-s) but effects would largely be analyzed qualitatively.

3.6.3.1.2.2 Impact Ranges from Sonar and Other Transducers

The following section provides ranges to specific effects from sonar and other transducers. Ranges are calculated using criteria from Table 3.6-4 and the Navy Acoustic Effects Model. Only ranges to TTS were predicted based on available data. Sonar durations of 1, 30, 60 and 120 seconds were used to calculate the ranges below. However, despite the variation in exposure duration, ranges were almost identical across these durations and therefore were combined and summarized by bin in the table below. General source levels, durations and other characteristics of these systems are described in Section 3.0.3.3.1 (Acoustic Stressors).

Ranges to TTS for mid-frequency sonar bins are only estimated for fishes with a swim bladder involved in hearing and fishes with high-frequency hearing. The maximum range to TTS is up to 10 m for these most sensitive hearing groups, but only for the most powerful sonar bins (e.g., MF1).

Table 3.6-4: Ranges to Temporary Threshold Shift from Four Representative Sonar Bins

Fish Hearing Group	*Range to Effects (meters)*			
	Sonar Bin LF5 Low-frequency	*Sonar Bin MF1 Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-61)*	*Sonar Bin MF4 Helicopter-deployed dipping sonars (e.g., AN/AQS-22)*	*Sonar Bin MF5 Active acoustic sonobuoys (e.g., DICASS)*
Fishes without a swim bladder	NR	NR	NR	NR
Fishes with a swim bladder not involved in hearing	0	NR	NR	NR
Fishes with a swim bladder involved in hearing	0	7 (5 - 10)	0	0
Fishes with a swim bladder and high-frequency hearing	0	7 (5 - 10)	0	0

Notes: NR = no criteria are available and therefore no range to effects are estimated.
Ranges to TTS represent modeled predictions in different areas and seasons within the Study Area. The average range to TTS is provided as well as the minimum to the maximum range to TTS in parenthesis. Where only one number is provided the average, minimum, and maximum ranges to TTS are the same.

3.6.3.1.2.3 Impacts from Sonar and Other Transducers under Alternative 1

Impacts from Sonar and Other Transducers under Alternative 1 for Training Activities

Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. Use of sonar and other transducers would typically be transient and temporary. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training under Alternative 1 are described in Section 3.0.3.3.1 (Acoustic Stressors). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activity Descriptions).

Under Alternative 1, the number of major training exercises, integrated/coordinated training activities, and civilian port defense activities would fluctuate annually. In addition, a portion of anti-submarine warfare tracking exercise –ship unit-level training activities would be conducted synthetically or in conjunction with other training exercises. Training activities using sonar and other transducers could occur throughout the Study Area, although use would generally occur in Navy range complexes and testing ranges, or around inshore locations identified in Chapter 2 (Description of Proposed Action and Alternatives). Use of sonars associated with anti-submarine warfare would be greatest in the Jacksonville and Virginia Capes Range Complexes.

Only a few species of shad within the Clupeidae family, subfamily Alosinae, are known to be able to detect high-frequency sonar and other transducers (greater than 10 kHz) and are considered a part of the fish hearing group for species with a swim bladder that have high-frequency hearing. Other marine fishes would probably not detect these sounds and therefore would not experience masking, physiological stress, or behavioral disturbance. Shad species, especially in nearshore and inland areas where mine warfare activities take place that often employ high-frequency sonar systems, could have behavioral reactions and experience masking during these events. However, mine warfare activities are typically limited in duration and geographic extent. Furthermore, sound from high-frequency systems may only be detectable above ambient noise regimes in these coastal habitats from within a few kilometers due to lower source levels and higher frequencies that do not propagate as far as other sonars. Behavioral reactions and masking, if they occurred for some shad and herring species, are expected to be transient and long-term consequences for populations would not be expected.

As discussed above, most marine fish species are not expected to detect sounds in the mid-frequency range (above a few kHz) of most operational sonars. The fish species that are known to detect mid-frequencies (i.e., those with swim bladders including some sciaenids [drum], most clupeids [herring, shad], and potentially deep-water fish such as myctophids [lanternfish]) do not have their best sensitivities in the range of the operational sonars. Thus, fishes may only detect the most powerful systems, such as hull-mounted sonar, within a few kilometers; and most other, less powerful mid-frequency sonar systems, for a kilometer or less. Fishes with a swim bladder involved in hearing and with high-frequency hearing are more susceptible to hearing loss due to exposure to mid-frequency sonars. However, the maximum estimated range to TTS for these fish hearing groups is equal to or less than 10 m for only the most powerful sonar bins. Fishes within these hearing groups would have to be very close to the source and the source levels would have to be relatively high in order to experience this effect.

Most mid-frequency active sonars used in the Study Area would not have the potential to substantially mask key environmental sounds or produce sustained physiological stress or behavioral reactions due to the limited time of exposure resulting from the moving sound sources and variable duty cycles. However, it is important to note that some mid-frequency sonars have a high duty cycle or are operated continuously. This may increase the risk of masking, but only for important biological sounds that overlap with the frequency of the sonar being operated. Furthermore, although some species may be able to produce sound at higher frequencies (greater than 1 kHz), vocal marine fishes, such as sciaenids, largely communicate below the range of mid-frequency levels used by most sonars. Any such effects would be temporary and infrequent as a vessel operating mid-frequency sonar transits an area. As such, mid-frequency sonar use is unlikely to impact individuals. Long-term consequences for fish populations due to exposure to mid-frequency sonar and other transducers are not expected.

All marine fish species can likely detect low-frequency sonars and other transducers. However, low-frequency active sonar use is limited and most low-frequency active operations are typically conducted in deeper, offshore areas. The majority of fish species, including those that are the most highly vocal, exist on the continental shelf and within nearshore, estuarine areas. However, some species may still be present in areas where low-frequency sonar and other transducers are used, including some coastal areas. Most low-frequency sonar sources do not have a high enough source level to cause TTS, as shown in Table 3.6-4. Although highly unlikely, if TTS did occur, it may reduce the detection of biologically significant sounds but would likely recover within a few minutes to days.

The majority of fish species exposed to sonar and other transducers within near (tens of meters) to far (thousands of meters) distances of the source would be more likely to experience mild physiological stress; brief periods of masking; behavioral reactions such as startle or avoidance responses, although risk would be low even close to the source; or no reaction. However, based on the information provided in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), the relative risk of these effects at any distance are expected to be low. Due to the transient nature of most sonar operations, overall effects would be localized and infrequent, only lasting a few seconds or minutes. Based on the low level and short duration of potential exposure to low-frequency sonar and other transducers, long-term consequences for fish populations are not expected.

As discussed previously in Section 3.6.2.1.3 (Hearing and Vocalization) and as shown in Figure 3.6-6, all ESA-listed fish species that occur in the Study Area are capable of detecting sound produced by low-frequency sonars and other transducers. Scalloped hammerhead sharks, smalltooth sawfish, giant manta ray, and oceanic whitetip sharks do not have a swim bladder and cannot detect frequencies above 1 kHz. It is assumed that fishes without a swim bladder cannot detect high-frequency sonars and may only detect mid-frequency sources below 2 kHz, with high source levels, and within close proximity to the source (a few tens of meters). Atlantic salmon, Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, and Nassau groupers have a swim bladder not involved in hearing and may be able to detect some mid-frequency sources below 2 kHz, but they are not particularly sensitive to these frequencies. Therefore, impacts from mid-, high- or very high-frequency sonar and other transducers are not expected for any ESA-listed species.

All ESA-listed species that occur in the Study Area may be exposed to low-frequency sonar or other transducers associated with training activities. Atlantic salmon could be exposed to sonar and other transducers but only in the Northeast Range Complex during seasonal migrations in the spring and summer. Because most low-frequency sonar is typically operated in deeper offshore areas, ESA-listed shortnose sturgeon would be less likely to be exposed to low-frequency sonar due to their occurrence in nearshore areas. Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish typically occur in nearshore areas as well but can also occur farther offshore. Despite their occurrence in nearshore areas, each of these species may still be present in areas where low-frequency sonar and other transducers are used. The Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead only occur in the eastern portion of the Key West Range Complex (southeastern part of the Study Area) and in the vicinity of Puerto Rico. Nassau groupers are also limited to these southeastern portions of the Study Area, specifically around Key West and other areas of Florida and Puerto Rico. These species would only have the potential to be impacted by activities in these areas. The ESA-listed giant manta ray and oceanic whitetip shark would most likely be exposed to low-frequency sonar in offshore areas throughout the Study Area.

Overall, impacts to ESA-listed species that encounter sonar or other transducers within their hearing range would be similar to those discussed above for impacts to fishes in general. As described above, most low-frequency sonar sources do not have a high enough source level to cause TTS and TTS would not be anticipated in fishes without a swim bladder. Although highly unlikely, if TTS did occur in fishes with a swim bladder, it may result in a reduction in detection of biologically significant sounds but would likely recover within a few minutes to days. ESA-listed species within the Study Area would be more likely to experience masking, physiological stress, and behavioral reactions, although risk would be low even close to the source. These impacts would be short term (seconds to minutes) for individuals and long-term consequences for populations would not be expected. Multiple exposures for individuals within a short period (seconds to minutes) are unlikely due to the transient nature of most sonar activities. Although some shark species have shown attraction to irregularly pulsed low-frequency sounds (below several hundred Hz), they are not known to be attracted to continuous signals or higher frequencies that they presumably cannot hear (Casper & Mann, 2006; Casper & Mann, 2009; Casper et al., 2012a).

Proposed training activities involving the use of sonar overlap designated critical habitat for Atlantic sturgeon in the James River at Naval Station Norfolk in Norfolk, VA. However, most of the designated physical and biological features do not occur within the Study Area and the use of sonar and other transducers would not affect any of the physical and biological features that have been identified.

Proposed training activities involving the use of sonar overlap designated critical habitat for Gulf sturgeon in the nearshore portion of the Panama City OPAREA. Most of the physical and biological features are generally not applicable to the Study Area since they occur within the riverine habitat of the species. Those that may occur within the Study Area include abundant prey items within marine habitats and safe and unobstructed migratory pathways between riverine, estuarine, and marine habitats. However, the use of sonar and other transducers would not affect any of the physical and biological features that have been identified.

Designated critical habitat for Atlantic salmon is restricted to rivers within Maine and does not overlap areas where sonar and other transducers are used. Likewise, designated critical habitat for smalltooth sawfish is restricted to nearshore, shallow waters (less than 1 m) around the tip of Florida and does not overlap areas where sonar and other transducers are used.

Pursuant to the ESA, the use of sonar and other transducers during training activities, as described under Alternative 1, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of sonar and other transducers during training activities, as described under Alternative 1, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta ray and oceanic whitetip sharks. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

Impacts from Sonar and Other Transducers under Alternative 1 for Testing Activities

General categories and characteristics of sonar systems and the number of hours these sonars would be operated during testing under Alternative 1 are described in Section 3.0.3.3.1 (Acoustic Stressors). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activity Descriptions).

Under Alternative 1, the number of testing activities would fluctuate annually. Testing activities using sonar and other transducers could occur throughout the Study Area, although use would generally occur within Navy range complexes, on Navy testing ranges, or around pierside locations identified in Chapter 2 (Description of Proposed Action and Alternatives). In particular, low-frequency sources occur in some coastal waters such as Newport, RI; the Naval Undersea Warfare Center Division, Newport Testing Range; offshore of Fort Pierce, FL; South Florida Ocean Measurement Facility; Naval Surface Warfare Center, Panama City Division Testing Range; as well as in any of the range complexes, with the exception of the Key West Range Complex, throughout the Study Area. Low-frequency sources are operated more frequently during testing activities than during training activities. Therefore, although the general impacts from sonar and other transducers during testing would be similar in severity to those described during training, there may be slightly more impacts during testing activities.

Hearing loss in fishes from exposure to sonar and other transducers is unlikely. Although unlikely, if TTS did occur, it would occur within tens of meters of the source and only in select hearing groups. The majority of fish species exposed to sonar and other transducers within near (tens of meters) to far (thousands of meters) distances of the source would be more likely to experience; mild physiological stress; brief periods of masking; behavioral reactions such as startle or avoidance responses, although risk would be low even close to the source; or no reaction. However, based on the information provided in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), the relative risk of these effects at any distance are expected to be low. Long-term consequences for individual fish are unlikely in most cases because acoustic exposures are intermittent, transient and unlikely to repeat over short periods. Since long-term consequences for most individuals are unlikely, long-term consequences for populations are not expected.

All ESA-listed fish species that occur in the Study Area have the potential to be exposed to sonar or other transducer use during testing activities, as activities involving these sources may occur in all range complexes, testing ranges, and at numerous inshore locations. The use of sonar in these coastal areas or at pierside locations may increase the likelihood of exposure for Atlantic salmon, Atlantic sturgeon, shortnose surgeon, smalltooth sawfish and Gulf sturgeon. Despite their occurrence in nearshore areas, each of these species may also be present in offshore areas where low-frequency sonar and other transducers are used. The Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead only occur in the eastern portion of the Key West Range Complex (southeastern part of the Study Area) and in the vicinity of Puerto Rico. Nassau groupers are also limited to these southeastern portions of the Study Area, specifically around Key West and other areas of Florida and Puerto Rico and, as such, would only likely be exposed to low-frequency sonar during its use at the South Florida Ocean Measurement Facility and offshore of Fort Pierce, FL. Due to this limited amount of overlap between range complexes and scalloped hammerhead shark and Nassau grouper habitat, exposure to sonar and other transducers would be extremely rare. ESA-listed giant manta ray and oceanic whitetip sharks would most likely be exposed to low-frequency sonar in offshore areas throughout the Study Area.

As discussed above, all ESA-listed fish species that occur in the Study Area are capable of detecting sound produced by low-frequency sonars and other transducers. Some ESA-species may only detect mid-frequency sources at below 2 kHz, but are not particularly sensitive to these frequencies. Therefore, impacts from mid-, high- or very high-frequency sonar and other transducers are not expected for any ESA-listed species.

Overall, impacts on ESA-listed species that encounter sonar or other transducers within their hearing range would be similar to those discussed for other fishes that occur in the Study Area. TTS would not be anticipated in fishes without a swim bladder. Most low-frequency sonar sources do not have a high enough source level to cause TTS. Although highly unlikely, if TTS did occur in fishes with a swim bladder, it may result in a reduction in detection of biologically significant sounds but would likely recover within a few minutes to days. Most ESA-species within the Study Area could experience masking, physiological stress, and behavioral reactions; however, the relative risk of these occurring is low and these impacts would be short term (seconds to minutes) for individuals. Multiple exposures for individuals within a short period (seconds to minutes) throughout most of the range complexes are unlikely due to the transient nature of sonar activities. Testing activities at pierside locations may increase the likelihood of repeated exposures. However, repeated exposures would only involve short-term (seconds to minutes) and minor behavioral impacts, which, repeated a few times per year, would still only lead to short term (seconds to minutes) impacts for individuals; long-term consequences for populations would not be expected.

Proposed testing activities involving the use of sonar overlap designated critical habitat for Atlantic sturgeon in the Kennebec River at Bath Iron Works in Bath, ME; in the Piscataqua River at Portsmouth Naval Shipyard in Kittery, ME; and in the James River at Naval Station Norfolk in Norfolk, VA. Most of the designated physical and biological features do not occur within the Study Area and the use of sonar and other transducers would not affect any of the physical and biological features that have been identified.

Proposed testing activities involving the use of sonar overlap designated critical habitat for Gulf sturgeon in the nearshore portions of the Naval Surface Warfare Center Panama City Division Testing Range and the Panama City OPAREA. Most of the physical and biological features are generally not applicable to the Study Area since they occur within the riverine habitat of the species. Those that may occur within the Study Area include abundant prey items within marine habitats and safe and unobstructed migratory pathways between riverine, estuarine and marine habitats. However, the use of sonar and other transducers would not affect any of the physical and biological features that do occur in the Study Area.

Proposed testing activities involving the use of sonar overlap critical habitat for Atlantic salmon in the Kennebec River near Bath Iron Works in Bath, ME. While the waters immediately surrounding Bath Iron Works are excluded from the critical habitat designation, sound produced by the sonars or other transducers may travel beyond the boundaries of the exclusion area. However, the use of sonar and other transducers would not affect any of the physical and biological features that have been identified.

Designated critical habitat for smalltooth sawfish is restricted to nearshore, shallow waters (less than 1 m) around the tip of Florida (see Figure 3.6-4) and does not overlap areas where sonar and other transducers are used.

Pursuant to the ESA, the use of sonar and other transducers during testing activities, as described under Alternative 1, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon and smalltooth sawfish. The use of sonar and other transducers during testing activities, as described under Alternative 1, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta rays and oceanic whitetip sharks. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

3.6.3.1.2.4 Impacts from Sonar and Other Transducers under Alternative 2

Impacts from Sonar and Other Transducers under Alternative 2 for Training Activities

Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. Use of sonar and other transducers would typically be transient and temporary. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training under Alternative 2 are described in Section 3.0.3.3.1 (Acoustic Stressors). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activity Descriptions).

Under Alternative 2, the maximum number of training activities could occur every year and all unit level training requirements would be completed at sea rather than synthetically. In addition, all unit level surface ship anti-submarine warfare training requirements would be completed through individual events conducted at sea, rather than through leveraging other anti-submarine warfare training exercises or the use of synthetic trainers. This would result in an increase of sonar use compared to Alternative 1. Training activities using sonar and other transducers could occur throughout the Study Area.

Impacts on fishes due to sonar and other transducers are expected to be limited to minor behavioral responses, short-term physiological stress, and brief periods of masking (seconds to minutes at most) for individuals; long-term consequences for individuals and therefore populations would not be expected. Predicted impacts on ESA-listed fish species and designated critical habitat would not be discernible from those described above in Section 3.6.3.1.2.3 (Impacts from Sonar and Other Transducers Under Alternative 1 for Training Activities).

Pursuant to the ESA, the use of sonar and other transducers during training activities, as described under Alternative 2, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of sonar and other transducers during training activities, as described under Alternative 1, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta ray and oceanic whitetip sharks.

Impacts from Sonar and Other Transducers under Alternative 2 for Testing Activities

General categories and characteristics of sonar systems and the number of hours these sonars would be operated during testing under Alternative 2 are described in Section 3.0.3.3.1 (Acoustic Stressors). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activity Descriptions).

Under Alternative 2, the maximum number of nearly all testing activities would occur every year. This would result in an increase of sonar use compared to Alternative 1. Testing activities using sonar and other transducers could occur throughout the Study Area, although use would generally occur within Navy range complexes, on Navy testing ranges, or around inshore locations identified in Chapter 2 (Description of Proposed Action and Alternatives).

Impacts on fishes due to sonar and other transducers are expected to be limited to minor behavioral responses, short-term physiological stress, and brief periods of masking (seconds to minutes) for individuals; long-term consequences for individuals and therefore populations would not be expected. Predicted impacts on ESA-listed fish species and designated critical habitat would not be discernible from those described above in Section 3.6.3.1.2.3 (Impacts from Sonar and Other Transducers Under Alternative 1 for Testing Activities).

Pursuant to the ESA, the use of sonar and other transducers during testing activities, as described under Alternative 2, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of sonar and other transducers during testing activities, as described under Alternative 2, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta rays and oceanic whitetip sharks.

3.6.3.1.2.5 Impacts from Sonar and Other Transducers under the No Action Alternative

Impacts from Sonar and Other Transducers under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various acoustic stressors (e.g., sonar and other transducers) would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment either would remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.1.3 Impacts from Air Guns

Fishes could be exposed to sounds from air guns during testing activities. General categories and characteristics of air guns and the number of hours these air guns will be operated are described in Section 3.0.3.3 (Identifying Stressors for Analysis). The activities analyzed in the EIS/OEIS that use air guns are also described in Appendix A (Navy Activity Descriptions).

As discussed in Section 3.6.2.1.3 (Hearing and Vocalization), most marine fish species hear primarily below 1 kHz. Fish species within each of the four fish hearing groups would likely be able to detect sounds produced by air guns. Exposure of fishes to air guns could result in direct injury, hearing loss, masking, physiological stress or behavioral reactions.

3.6.3.1.3.1 Methods for Analyzing Impacts for Air Guns

The Navy performed a quantitative analysis to estimate range to effects for fishes exposed to air guns during Navy testing activities. Inputs to the quantitative analysis included sound propagation modeling in the Navy's Acoustic Effects Model to the sound exposure criteria and thresholds presented below. Although range to effects are predicted, density data for fish species within the Study Area are not available; therefore, it is not possible to estimate the total number of individuals that may be affected by sound produced by air guns.

Criteria and Thresholds Used to Estimate Impacts from Air Guns

Mortality and Injury from Air Guns

Criteria and thresholds to estimate impacts from sound produced by air gun activities are presented below in Table 3.6-5. Consistent with the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), dual metric sound exposure criteria are utilized to estimate mortality and injury from exposure to air guns. For purposes of this analysis, it is assumed that a specified effect will occur when either metric (cumulative sound exposure level or peak sound pressure level) is met or exceeded. Due to the lack of detailed data on injury thresholds in fishes exposed to air guns, thresholds form impact pile driving exposures are used as a proxy for this analysis (Halvorsen et al., 2011; Halvorsen et al., 2012a; Halvorsen et al., 2012b). General research findings regarding mortality and injury in fishes are discussed under Section 3.6.3.1.1.1 (Injury due to Impulsive Sound Sources).

As discussed under Section 3.6.3.1.1.1 (Injury due to Impulsive Sound Sources), injury and mortality in fishes exposed to impulsive sources may vary depending on the presence or absence of, and type of swim bladder. Injury and mortal injury has not been observed in fishes without a swim bladder because of exposure to impulsive sources (Halvorsen et al., 2011; Halvorsen et al., 2012a). Therefore, these effects would likely occur above the given thresholds in Table 3.6-5. Cumulative sound exposure thresholds for mortality and injury in fishes with a swim bladder were measured by investigators (Halvorsen et al., 2011; Halvorsen et al., 2012a; Halvorsen et al., 2012b). However, only the single strike peak sound pressure level was measured during these experiments; therefore, mortality and injury thresholds are assumed to be the same across all hearing groups with a swim bladder (Popper et al., 2014).

Table 3.6-5: Sound Exposure Criteria for Mortality and Injury from Air Guns

Fish Hearing Group	Onset of Mortality		Onset of Injury	
	SEL_{cum}	SPL_{peak}	SEL_{cum}	SPL_{peak}
Fishes without a swim bladder	> 219	> 213	> 216	> 213
Fishes with a swim bladder not involved in hearing	210	> 207	203	> 207
Fishes with a swim bladder involved in hearing	207	> 207	203	> 207
Fishes with a swim bladder and high-frequency hearing	207	> 207	203	> 207

Notes: SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), SPL_{peak} = Peak sound pressure level (decibel referenced to 1 micropascal [dB re 1 μPa]), ">" indicates that the given effect would occur above the reported threshold.

Hearing Loss from Air Guns

Criteria and thresholds to estimate TTS in fishes exposed to sound produced by air guns are presented below in Table 3.6-6 and are consistent with the thresholds presented in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014). General research findings regarding hearing loss in fishes are discussed under Section 3.6.3.1.1.2 (Hearing Loss due to Impulsive Sound Sources).

As discussed in Section 3.6.3.1.1.2 (Hearing Loss), exposure to sound produced from an air gun at a cumulative sound exposure level of 186 dB re 1 μPa^2-s has resulted in TTS in fishes (Popper et al., 2005). TTS is not likely to occur in fishes without a swim bladder and would likely occur above the given threshold in Table 3.6-6 for fishes with a swim bladder not involved in hearing.

Table 3.6-6: Sound Exposure Criteria for TTS from Air Guns

Fish Hearing Group	TTS (SEL_{cum})
Fishes without a swim bladder	NC
Fishes with a swim bladder not involved in hearing	> 186
Fishes with a swim bladder involved in hearing	186
Fishes with a swim bladder and high-frequency hearing	186

Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), NC = effects from exposure to sound produced by air guns is considered to be unlikely, therefore no criteria are reported, ">" indicates that the given effect would occur above the reported threshold.

Impact Ranges for Air Guns

The following section provides to range to effects for fishes exposed to air gun activities. The majority of air gun activities occur offshore and involve the use of a single shot or 10 shots. Fewer activities are conducted pierside and could use up to a maximum of 100 shots. The following ranges are based on the SEL metrics for PTS and TTS for 100 firing of an air gun, a conservative estimate of the number of air gun firings that could occur over a single exposure duration at a single location. Table 3.6-7 presents the approximate ranges in meters to mortality (specific to the AFTT Study Area and to each fish hearing group), onset of injury, and TTS and are calculated using criteria (shown in Table 3.6-5 and Table 3.6-6) and the Navy Acoustic Effects Model. Range to effects for each hearing group may vary depending on the available criteria or other factors such as location of the activity, season the activity occurs, or depth of the activity.

Table 3.6-7: Range to Effect for Fishes Exposed to 100 Air Gun Shots

Fish Hearing Group	*Rang to Effects (meters)*				
	Onset of Mortality		*Onset of Injury*		*TTS*
	SEL_{cum}	*SPL_{peak}*	*SEL_{cum}*	*SPL_{peak}*	*SEL_{cum}*
Fishes without swim bladders	0	< 5 (4—13)	0 (0—2)	< 5 (4—13)	NR
Fishes with swim bladders not involved in hearing	0	< 9 (8—21)	1 (0—30)	< 9 (8—21)	< 14 (4—190)
Fishes with swim bladders involved in hearing	1 (0—1)	< 9 (8—21)	1 (0—30)	< 9 (8—21)	14 (4—190)
Fishes with high-frequency hearing	1 (0—1)	< 9 (8—21)	1 (0—30)	< 9 (8—21)	14 (4—190)

Notes: SEL_{cum} = Cumulative sound exposure level, SPL_{peak} = Peak sound pressure level, TTS = Temporary Threshold Shift, NR = no criteria are available and therefore no range to effects are estimated, "<" indicates that the given effect would occur as distances less than the reported range(s).

Range to effects represent modeled predictions in different areas and seasons within the Study Area. Each cell contains the estimated average, minimum and maximum range to the specified effect.

Mortality or injury could occur in all fishes with a swim bladder from exposure to air guns within or less than a maximum of 21 or 30 m, respectively. These effects would only occur in fishes without a swim bladder out to a distance less than 13 m. Hearing loss may occur in fishes with a swim bladder from exposure to air gun activities out to an average of 14 m or less, depending on the hearing group. In some cases, these effects may occur out to a maximum of 190 m. Hearing loss is not anticipated to occur in fishes without a swim bladder. The probability of these effects would decrease with increasing distance from the pile.

3.6.3.1.3.2 Impacts from Air Guns under Alternative 1

<u>Impacts from Air Guns under Alternative 1 for Training Activities</u>

Training activities under Alternative 1 do not include the use of air guns.

<u>Impacts from Air Guns under Alternative 1 for Testing Activities</u>

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.3.3 (Identifying Stressors for Analysis) and Appendix A (Navy Activity Descriptions), testing activities under Alternative 1 would include the use of single air guns pierside at the Naval Undersea Warfare Center Division, Newport Testing Range, and at off-shore locations typically in the Northeast, Virginia Capes, and Gulf of Mexico Range Complexes.

Impulses from air guns lack the strong shock wave and rapid pressure increases known to cause primary blast injury or barotrauma during explosive events and (to a lesser degree) impact pile driving. Although data from impact pile driving are often used as a proxy to estimate effects to fish from air guns, this may be an overly conservative metric due to the differences in rise times between the two types of impulsive sources. Typically, impact pile driving signals have a much steeper rise time and higher peak pressure than air gun signals. While mortality, injury, or TTS may occur at the individual level because of air gun activities, considering the small estimated footprint of the mortality/injury zone (see Table 3.6-7) and the isolated and infrequent use of air guns, population-level consequences would not be expected.

Air guns produce broadband sounds; however, the duration of an individual impulse is about 1/10th of a second. Masking could potentially occur as a result of exposure to sound produced by air guns. However, due to the brief nature of each pulse, it is unlikely that fishes within relatively close distance of the source (tens to hundreds of meters) to experience these effects. It is more likely that masking would occur at farther distances from the source where signals may sound continuous. This may result in brief periods where fishes are unable to detect vocalizations from other fish and predators. Fishes may also respond by altering their vocalizations to compensate for the noise. However, these effects would only occur if air gun signals are detectable over the existing ambient noise.

In addition, fish that are able to detect the air gun impulses may exhibit signs of physiological stress or alterations in natural behavior. Some fish species with site fidelity such as reef fish may show initial startle reactions, returning to normal behavioral patterns within a matter of a few minutes. Pelagic and schooling fish that typically show less site fidelity may avoid the immediate area for the duration of the events. Multiple exposures to individuals (across days) are unlikely as air guns are not operated in the same areas from day to day, but rather would be utilized in different areas over time. Due to the limited use and relatively small footprint of air guns, impacts on fish are expected to be minor. Population consequences would not be expected.

As discussed previously in 3.6.2.1.3 (Hearing and Vocalization), all ESA-listed fish species that occur in the Study Area are capable of detecting sound produced by air guns. Air gun activities associated with testing under Alternative 1 do not overlap areas where the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark or Nassau grouper occur and therefore would not affect either species. ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, shortnose sturgeon, smalltooth sawfish, giant manta ray and oceanic whitetip sharks could be exposed to sound from air guns associated with testing activities. Specifically, salmon, sturgeon and sawfish exposures would only occur in the Northeast, Virginia Capes, and Gulf of Mexico Range Complexes, and in Newport, RI. However, based on the low annual number of activities to occur in the Study Area and the short period of time (spring months) during the year that Atlantic salmon are present, the likelihood of exposure to testing activities is expected to be infrequent throughout a given year. Only sub adult and adult life phase Atlantic and Gulf sturgeon occur in offshore areas where air gun activities occur.

Overall, impacts on ESA-listed species that encounter air gun activities would be similar to those discussed for other fishes that occur in the Study Area. ESA-listed fishes could potentially suffer mortality or injury, with the probability and severity increasing closer to the air gun. Although there are estimated ranges to mortality and injury, on average, these ranges are relatively short (less than 10 m) across all fish hearing groups, further reducing the likelihood that mortality or injury would occur due to exposure to air gun activities. It is more likely that ESA-listed fishes that are exposed to air gun activities would result in behavioral reactions or physiological stress depending on their proximity to the activity. As described in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), masking effects within hundreds of meters from the source would be highly unlikely due to the short duration of the signal pulse.

Designated critical habitat for Atlantic salmon and Atlantic sturgeon is restricted to rivers within Maine and within estuarine and river systems, respectively, and does not overlap areas where air guns are used. Likewise, designated critical habitat for smalltooth sawfish is restricted to nearshore, shallow waters (less than 1 m) around the tip of Florida and does not overlap areas where air guns are used. Although designated critical habitat for Gulf sturgeon overlaps with portions of the Study Area, specifically in the nearshore areas of the Naval Surface Warfare Center Panama City Testing Range and the Panama City OPAREA, air gun activities do not occur in these areas.

Pursuant to the ESA, the use of air guns during testing activities, as described under Alternative 1, will have no effect on ESA-listed Nassau grouper, the Central and Southwestern Atlantic Distinct Population Segment of the scalloped hammerhead shark, or designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of air guns during testing activities, as described under Alternative 1, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, shortnose sturgeon, smalltooth sawfish, giant manta rays and oceanic whitetip sharks. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

3.6.3.1.3.3 Impacts from Air Guns under Alternative 2

Impacts from Air Guns under Alternative 2 for Training Activities

Training activities under Alternative 2 do not include the use of air guns.

Impacts from Air Guns under Alternative 2 for Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.3.3 (Identifying Stressors for Analysis) and Appendix A (Navy Activity Descriptions), testing activities under Alternative 2 would include activities that produce in-water noise from the use of air guns. Testing activities under Alternative 2 would be identical to those described under Alternative 1; therefore, the locations, types, and severity of predicted impacts would be identical to those described above under 3.6.3.1.3.2 (Impacts from Air Guns under Alternative 1 for Testing Activities).

Designated critical habitat for Atlantic salmon and Atlantic sturgeon is restricted to rivers within Maine and within estuarine and river systems, respectively, and does not overlap areas where air guns are used. Likewise, designated critical habitat for smalltooth sawfish is restricted to nearshore, shallow waters (less than 1 m) around the tip of Florida and does not overlap areas where air guns are used. Although designated critical habitat for Gulf sturgeon overlaps with portions of the study area, specifically in the nearshore areas of the Naval Surface Warfare Center Panama City Testing Range and the Panama City OPAREA, air gun activities do not occur in these areas.

Pursuant to the ESA, the use of air guns during testing activities, as described under Alternative 2, will have no effect on ESA-listed Nassau grouper, the Central and Southwestern Atlantic Distinct Population Segment of the scalloped hammerhead shark, or designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of air guns during testing activities, as described under Alternative 2, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, shortnose sturgeon, smalltooth sawfish, giant manta rays and oceanic whitetip sharks.

3.6.3.1.3.4 Impacts from Air Guns under the No Action Alternative

Impacts from Air Guns under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various acoustic stressors (i.e., air guns) would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment either would remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.1.4 Impacts from Pile Driving

Fishes could be exposed to sounds produced by impact pile driving and vibratory pile extraction activities during the construction and removal phases of the Elevated Causeway System described in Chapter 2 (Description of Proposed Action and Alternatives), and Appendix A (Navy Activity Descriptions). The training involves the use of an impact hammer to drive the 24-inch steel piles into the sediment and a vibratory hammer to remove later the piles that support the causeway structure. The impulses can produce a shock wave that is transmitted to the sediment and water column (Reinhall & Dahl, 2011). Elevated Causeway System pile installation and removal within the project area would result in a short-term increase in underwater noise levels (approximately one month out of a year). Section 3.0.3.3.1.3 (Pile Driving) provides additional details on pile driving and noise levels measured from similar operations. Pile driving activities produce broadband sound, therefore it is anticipated that all fishes within each fish hearing group discussed in Section 3.6.2.1.3 (Hearing and Vocalization) would likely be able to detect sound produced by impact pile driving and vibratory pile extraction activities. Exposure of fishes to pile driving activities could result in direct injury, hearing loss, masking, physiological stress or behavioral reactions.

3.6.3.1.4.1 Methods for Analyzing Impact from Pile Driving

The Navy performed a quantitative analysis to estimate the range to effect for fishes exposed to impact pile driving during Navy training activities. Inputs to the quantitative analysis included basic sound propagation modeling and sound exposure criteria and thresholds presented below. Although range to effects are predicted, density data for fish species within the Study Area are not available; therefore, it is not possible to estimate the total number of individuals that may be affected by sound produced by impact pile driving.

Currently, there are no proposed criteria for vibratory pile extraction activities and therefore these activities are analyzed based on available literature and other observed reactions.

<u>Criteria and Thresholds Used to Estimate Impacts from Pile Driving</u>

Mortality and Injury from Pile Driving

Criteria and thresholds to estimate impacts from sound produced by impact pile driving activities are presented below in Table 3.6-8. Consistent with the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), dual metric sound exposure criteria are utilized to estimate mortality and injury from exposure to impact pile driving. For purposes of this analysis, it is assumed that a specified effect will occur when either metric (cumulative sound exposure level or peak sound pressure level) is met or exceeded. General research findings regarding mortality and injury in fishes as well as findings specific to exposure to other impulsive sound sources are discussed under Section 3.6.3.1.1.1 (Injury due to Impulsive Sound Sources).

Table 3.6-8: Sound Exposure Criteria for Mortality and Injury from Impact Pile Driving

Fish Hearing Group	Onset of Mortality		Onset of Injury	
	SEL_{cum}	SPL_{peak}	SEL_{cum}	SPL_{peak}
Fishes without a swim bladder	> 219	> 213	> 216	> 213
Fishes with a swim bladder not involved in hearing	210	> 207	203	> 207
Fishes with a swim bladder involved in hearing	207	> 207	203	> 207
Fishes with a swim bladder and high-frequency hearing	207	> 207	203	> 207

Notes: SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), SPL_{peak} = Peak sound pressure level (decibel referenced to 1 micropascal [dB re 1 µPa]), ">" indicates that the given effect would occur above the reported threshold.

An explanation of mortality and injury criteria are also available under Section 3.6.3.1.3.1 (Methods for Analyzing Impacts for Air Guns – Mortality and Injury from Air Guns).

Hearing Loss from Pile Driving

Criteria and thresholds to estimate TTS in fishes exposed to sound produced by impact pile driving activities are presented below in Table 3.6-9. Sound exposure thresholds are available in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) and inform the TTS thresholds presented here. Due to the lack of data on hearing loss in fishes exposed to impact pile driving, data from air gun studies were used as a proxy for this analysis (Popper et al., 2005). General research findings regarding hearing loss in fishes are discussed under Section 3.6.3.1.1.2 (Hearing Loss due to Impulsive Sound Sources).

Table 3.6-9: Sound Exposure Criteria for TTS from Impact Pile Driving

Fish Hearing Group	TTS (SEL_{cum})
Fishes without a swim bladder	NC
Fishes with a swim bladder not involved in hearing	> 186
Fishes with a swim bladder involved in hearing	186
Fishes with a swim bladder and high-frequency hearing	186

Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), NC = effects from exposure to sound produced by impact pile driving is considered to be unlikely, therefore no criteria are reported, ">" indicates that the given effect would occur above the reported threshold.

An explanation of hearing loss criteria is also available under Section 3.6.3.1.3.1 (Methods for Analyzing Impacts for Air Guns – Hearing Loss from Air Guns).

Modeling of Pile Driving Noise

Underwater noise effects from pile driving and vibratory pile extraction were modeled using actual measures of impact pile driving and vibratory removal during construction of an elevated causeway (Illingworth and Rodkin, 2015, 2017). A conservative estimate of spreading loss of sound in shallow coastal waters (i.e., transmission loss = 16.5*Log10[radius]) was applied based on spreading loss observed in actual measurements. Inputs used in the model are provided in Section 3.0.3.3.1.3 (Pile Driving), including source levels; the number of strikes required to drive a pile and the duration of vibratory removal per pile; the number of piles driven or removed per day; and the number of days of pile driving and removal.

3.6.3.1.4.2 Impact Ranges for Pile Driving

The following section provides range to effects for fishes exposed to impact pile driving to specific criteria determined using the calculations and modeling described above. Fishes within these ranges would be predicted to receive the associated effect. Where effects are anticipated to occur above the designated criteria (see Table 3.6-10), the estimated ranges to that effect would be less than those displayed in the table.

Because of the static nature of pile driving activities, two different exposure times were used when calculating range to effects for different types of fish (e.g., transient species vs. species with high site fidelity). It is assumed that some transient fishes (e.g., pelagic species) would likely move through the area during pile driving activities, resulting in less time exposed. Therefore, range to effects for these species are estimated based on 35 strikes per minute, for a cumulative exposure time of one minute (see Table 3.6-10). In addition, it is assumed that ranges to mortality or injury would actually be less than the ranges shown in the table due to the criteria, which informed the range calculations.

Table 3.6-10: Impact Ranges for Transient Fishes from Impact Pile Driving for 35 Strikes (1 minute)

Fish Hearing Group	*Range to Effects (meters)*				
	Onset of Mortality		*Onset of Injury*		*TTS*
	SEL_{cum}	*SPL_{peak}*	*SEL_{cum}*	*SPL_{peak}*	*SEL_{cum}*
Fishes without a swim bladder	< 1	< 8	< 1	< 8	NR
Fishes with a swim bladder not involved in hearing	2	< 17	5	< 17	< 57
Fishes with a swim bladder involved in hearing	3	< 17	5	< 17	57
Fishes with a swim bladder and high-frequency hearing	3	< 17	5	< 17	57

Notes: SEL_{cum} = Cumulative sound exposure level, SPL_{peak} = Peak sound pressure level, TTS = Temporary Threshold Shift, NR = no criteria are available and therefore no range to effects are estimated, “<” indicates that the given effect would occur at distances less than the reported range(s).

Based on the measured sound levels for pile driving, mortality or injury could occur in transient or pelagic fishes with a swim bladder from exposure to impact pile driving at a distance less than 17 m of the source. In addition, it is assumed that these fishes may also experience signs of hearing loss out to a distance of, or less than, 57 m depending on the fish hearing group. The probability of these effects would decrease with increasing distance from the pile. Fishes without a swim bladder would not likely experience TTS and would only have the potential for mortality or injury effects at a distance less than 8 m of the source.

In contrast, it is assumed that fish with high site fidelity (e.g., demersal or reef fish) may stay in the area during pile driving activities and therefore may receive a longer exposure. As a conservative measure, ranges in Table 3.6-11 were calculated based on an estimated 3,150 strikes over the course of an entire day.

Table 3.6-11: Impact Ranges for Fishes with High Site Fidelity from Impact Pile Driving for 3,150 strikes (1 Day)

Fish Hearing Group	Range to Effects (meters)				
	Onset of Mortality		Onset of Injury		TTS
	SEL_{cum}	SPL_{peak}	SEL_{cum}	SPL_{peak}	SEL_{cum}
Fishes without a swim bladder	< 9	< 8	< 13	< 8	NR
Fishes with a swim bladder not involved in hearing	30	< 17	81	< 17	< 868
Fishes with a swim bladder involved in hearing	46	< 17	81	< 17	868
Fishes with a swim bladder and high-frequency hearing	46	< 17	81	< 17	868

Notes: SEL_{cum} = Cumulative sound exposure level, SPL_{peak} = Peak sound pressure level, TTS = Temporary Threshold Shift, NR = no criteria are available and therefore no range to effects are estimated, < indicates that effects would occur at distances less than the provided range.

Under the assumption that fish are stationary and remain in the area for the duration of a full day of pile driving activities, mortality and injury could occur from exposure to impact pile driving within a maximum distance of 46 m and potentially out to 81 m from the source, respectively, for species within the most sensitive hearing groups (i.e., fishes with a swim bladder involved in hearing and fishes with high-frequency hearing). In addition, fishes with a swim bladder may also experience signs of hearing loss out to 868 m. The probability of these effects would decrease with increasing distance from the pile. Fishes without a swim bladder would not likely experience TTS and would only have the potential for mortality or injury effects within 9 or 13 m of the source, respectively.

3.6.3.1.4.3 Impacts from Pile Driving under Alternative 1

<u>**Impacts from Pile Driving under Alternative 1 for Training Activities**</u>

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.6-1, Section 3.0.3.3 (Identifying Stressors for Analysis), and Appendix A (Navy Activity Descriptions), training activities under Alternative 1 include pile driving associated with construction and removal of the Elevated Causeway System. This activity would take place nearshore and within the surf zone for up to 30 days (20 days for construction and 10 days for removal). Specifically, pile driving activities would only occur once at Joint Expeditionary Base Little Creek-Fort Story, Virginia, and once at Marine Corps Base Camp Lejeune, North Carolina, per year. The pile driving locations are within coastal areas that tend to have high ambient noise levels due to natural and anthropogenic sources.

Impulses from the impact hammer are broadband and carry most of their energy in the lower frequencies. The impulses are within the hearing range of all fish, and in close proximity exhibit an overpressure shock front in the water due to the high-speed travel of the impact pressure wave down and back up the steel pile (Reinhall & Dahl, 2011). The impulse can also travel through the bottom sediment. Fishes may be exposed to sound or energy from impact and vibratory pile driving associated with training activities throughout the year.

Range to effects for fishes with high site fidelity are generally longer than those reported for transient fishes due to the differences in cumulative exposure time (see Table 3.6-10 and Table 3.6-11). However, it is not likely that either type of fish would remain close enough to a pile driving source for an entire day or long enough to result in mortality or injury. In some cases, based on behavioral response data to impulsive sources, as described in Section 3.6.3.1.1.5 (Behavioral Reactions), individuals that do startle or avoid the immediate area surrounding a pile driving activity would likely habituate and return to normal behaviors after initial exposure. Signs of hearing loss however may occur in fishes exposed to initial pile driving activities. Fishes that experience hearing loss may have reduced ability to detect biologically important sounds until their hearing recovers. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. As discussed in Section 2.3.3.14 (Pile Driving Safety), as a standard operating procedure, the Navy performs soft starts at reduced energy during an initial set of strikes from an impact hammer. Soft starts may “warn” fish and cause them to move away from the sound source before impact pile driving increases to full operating capacity. Considering the small footprint of this injury zone and standard operating procedure for soft starts, long-term consequences to transient individuals, and therefore population consequences, would not be expected. Fishes with high site fidelity would be at more risk to experience effects from impact pile driving, but these effects would also not be likely to result in population level consequences.

Fishes exposed to vibratory extraction would not likely result in mortality, injury, or TTS based on the low source level and limited duration of these activities as discussed in Section 3.0.3.3.1.3 (Pile Driving). Based on the predicted impact pile driving and vibratory extraction noise levels, fishes may also exhibit other responses such as masking, physiological stress, or behavioral responses. Masking only occurs when the interfering signal is present; however, impact pile driving activities are intermittent. Therefore, masking would be localized and of limited duration during impact pile driving. Fishes may habituate, or choose to tolerate pile driving sound after multiple strikes, returning to normal behavior patterns during the pile driving activities. Vibratory pile extraction is more likely than impact pile driving to cause masking of environmental sounds; however, due to its low source level, the masking effect would only be relevant in a small area around the vibratory pile extraction activity. Fishes may also react to pile driving and vibratory pile extraction sound by increasing their swimming speed, moving away from the source, or not responding at all.

As discussed previously (Section 3.6.2.1.3, Hearing and Vocalization), all ESA-listed fish species that occur in the Study Area are capable of detecting sound produced by pile driving activities. Pile driving activities associated with training under Alternative 1 do not overlap with Atlantic salmon, Gulf sturgeon, Nassau grouper, oceanic whitetip shark, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead shark, or smalltooth sawfish habitat. Atlantic sturgeon, shortnose sturgeon, and giant manta ray could be exposed to sound or substrate vibration from pile driving associated with training activities. These exposures would only occur in either Joint Expeditionary Base Little Creek-Fort Story, Virginia, or Marine Corps Base Camp Lejeune, North Carolina, for up to 30 days (20 days for construction and 10 days for removal) at either location in any given year.

Atlantic sturgeon, shortnose sturgeon, and giant manta ray, if close enough to pile driving, could potentially suffer mortality, injury or hearing loss with the probability and severity increasing closer to the pile driving activity (see Table 3.6-10 and Table 3.6-11 for range to effects). However, it is unlikely that exposed individuals would move closer to the source after initial exposure, nor would manta rays remain within these zones for an entire day. Masking, physiological stress or behavioral reactions are also possible due to pile driving or vibratory pile extraction. Atlantic sturgeon and giant manta rays that are exposed to pile driving activities may habituate, or choose to tolerate the sound after multiple strikes or after multiple pile removals, returning to normal behavior patterns during the pile driving activities. Although Atlantic sturgeon, shortnose sturgeon, and giant manta ray may be affected, long-term consequences for populations would not be expected.

Designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish does not overlap with areas where pile driving activities will occur.

Pursuant to the ESA, the use of pile driving during training activities, as described under Alternative 1, will have no effect on ESA-listed Atlantic salmon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, smalltooth sawfish, oceanic whitetip sharks, or designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of pile driving during training activities, as described under Alternative 1, may affect ESA-listed Atlantic sturgeon, shortnose sturgeon, and giant manta rays. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

Impacts from Pile Driving under Alternative 1 for Testing Activities

Testing activities under Alternative 1 do not include the use of pile driving (impact or vibratory).

3.6.3.1.4.4 Impacts from Pile Driving under Alternative 2

Impacts from Pile Driving under Alternative 2 for Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.3.3 (Identifying Stressors for Analysis), and Appendix A (Navy Activity Descriptions), training activities under Alternative 2 include activities that produce in-water sound from the pile driving. Training activities under Alternative 2 would be identical to those described under Alternative 1; therefore, the locations, types, and severity of predicted impacts would be identical to those described above under Section 3.6.3.1.4.3 (Impacts from Pile Driving Under Alternative 1 for Training Activities).

Pursuant to the ESA, the use of pile driving during training activities, as described under Alternative 2, will have no effect on ESA-listed Atlantic salmon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, smalltooth sawfish, oceanic whitetip sharks, or designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of pile driving during training activities, as described under Alternative 2, may affect ESA-listed Atlantic sturgeon, shortnose sturgeon, and giant manta rays.

Impacts from Pile Driving under Alternative 2 for Testing Activities

Testing activities under Alternative 2 do not include the use of pile driving (impact or vibratory).

3.6.3.1.4.5 Impacts from Pile Driving under the No Action Alternative

Impacts from Pile Driving under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various acoustic stressors (e.g., impact pile driving and vibratory pile extraction) would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment either would remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.1.5 Impacts from Vessel Noise

Fishes may be exposed to sound from vessel movement. A detailed description of the acoustic characteristics and typical sound produced by vessels is in Section 3.0.3.3 (Identifying Stressors for Analysis). Vessel movements involve transits to and from ports to various locations within the Study Area. Many ongoing and proposed training and testing activities within the Study Area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels), as well as unmanned vehicles. Moderate- to low-level passive sound sources including vessel noise are unlikely to cause any direct injury or trauma due to characteristics of the sounds and the moderate source levels as discussed in Section 3.0.3.3.1 (Acoustic Stressors). Furthermore, although hearing loss because of continuous noise exposure has occurred, vessels are transient and would result in only brief periods of exposure. Injury and hearing loss because of exposure to vessel noise is not discussed further in this analysis.

As discussed in Section 3.6.2.1.3 (Hearing and Vocalization), all fish species should be able to detect vessel noise due to its low-frequency content and their hearing capabilities. Exposure to vessel noise could result in short-term behavioral or physiological responses (e.g., avoidance, stress) as discussed in Section 3.6.3.1.1.3 (Masking), Section 3.6.3.1.1.4 (Physiological Stress), and Section 3.6.3.1.1.5 (Behavioral Reactions).

Training and testing events involving vessel movements occur intermittently and range in duration from a few hours up to a few weeks. These activities are widely dispersed throughout the Study Area. The exception is for pierside activities, although these areas are located inshore, these are industrialized areas that are already exposed to high levels of anthropogenic noise due to numerous waterfront users (e.g., commercial properties, ports, marinas). Ships would produce low-frequency, broadband underwater sound below 1 kHz while smaller vessels would emit higher-frequency sound between 1 kHz and 50 kHz, though the exact level of sound produced varies by vessel type. Navy vessels make up a very small percentage of the overall traffic (Mintz, 2012), and the rise of ambient noise levels in the Study Area is a problem related to all ocean users, including commercial and recreational vessels and shoreline development and industrialization. Fishes could be exposed to a range of impacts depending on the source of vessel noise and context of the exposure. Specifically, impacts from exposure to vessel noise may include temporary hearing loss, auditory masking, physiological stress, or changes in behavior.

3.6.3.1.5.1 Methods for Analyzing Impacts from Vessel Noise

The impacts on fishes due to exposure to vessel noise are analyzed qualitatively by comparing reported observations under specific conditions as discussed in Section 3.6.3.1.1 (Background) to the conditions which fishes may be exposed to during proposed Navy activities.

3.6.3.1.5.2 Impacts from Vessel Noise under Alternative 1

Impacts from Vessel Noise under Alternative 1 for Training Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives) and Section 3.0.3.3.1.4 (Vessel Noise), training activities under Alternative 1 include vessel movement in many events. Navy vessel traffic could occur anywhere within the Study Area, but would be concentrated near the Norfolk and Mayport Navy ports and within the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes. A study of Navy vessel traffic found that traffic was heaviest just offshore between the mouth of the Chesapeake Bay and Jacksonville, FL, with very little Navy vessel traffic in the Northeast or Gulf of Mexico Range Complexes (Mintz, 2012).

As described in Section 3.6.2.1.3 (Hearing and Vocalization), an increase in background noise levels from training and testing activities have the potential to expose fishes to sound and general disturbance, potentially resulting in short-term physiological stress, masking, or behavioral reactions. Fishes are more likely to react to nearby vessel noise (i.e., within tens of meters) than to vessel noise emanating from a distance. Fishes may have physiological stress reactions to sounds they can hear but typically, responses would be brief and would not affect the overall fitness of the animal. Auditory masking due to vessel noise can potentially mask vocalizations and other biologically important sounds (e.g., sounds of prey or predators) that fish may rely on. The low-frequency sounds of large vessels or accelerating small vessels can cause avoidance responses by fishes. However, impacts from vessel noise would be temporary and localized, and such responses would not be expected to compromise the general health or condition of individual fish. Therefore, long-term consequences for populations are not expected.

All ESA-listed species that occur in the Study Area are likely capable of detecting vessel noise as discussed previously in Section 3.6.2.1.3 (Hearing and Vocalization). Atlantic salmon may be exposed to vessel sound from training activities throughout the year in the Northeast Range Complexes. Atlantic sturgeon exposures could occur at any inshore training area in the Northeast, Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes, particularly in the Chesapeake Bay and in the St. Marys River near Naval Submarine Base Kings Bay, GA. Shortnose sturgeon, which primarily inhabit rivers and estuaries, are not expected to occur in the off shore portions of the Study Area (Dadswell, 2006; National Marine Fisheries Service, 1998). However, exposures could occur in the Northeast, Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes. Smalltooth sawfish and Gulf sturgeon exposures could occur in the Gulf of Mexico Range Complexes. Smalltooth sawfish could also be exposed to vessel noise in the Jacksonville and Key West Range Complexes. The Central and SW Atlantic distinct population segment of scalloped hammerhead sharks and Nassau grouper may be exposed to vessel noise associated with training activities throughout the year in the Key West Range Complex and in waters in the vicinity of Puerto Rico and the U.S. Virgin Islands. In addition, Nassau grouper may also be exposed to vessel noise associated with training activities throughout the year in the Jacksonville Range Complex. Giant manta ray and oceanic whitetip sharks may also be exposed throughout the Study Area. If exposure to vessel noise did occur, ESA-listed species could experience behavioral reactions, physiological stress, and masking, although these impacts would be expected to be short term and infrequent based on the low probability of co-occurrence between vessel activity and species. Long-term consequences for populations would not be expected.

Proposed training activities that produce vessel noise overlap designated critical habitat for Atlantic sturgeon in a number of areas including; Kennebec River, ME; James River, VA; York River, VA; Cooper River, SC; and St. Marys River, GA. Most of the designated physical and biological features do not occur within the Study Area and vessel noise would not affect any of the physical and biological features that have been identified.

Proposed training activities that produce vessel noise overlap designated critical habitat for Gulf sturgeon in the nearshore portions of the Panama City OPAREA. A map of critical habitat is available in Section 3.6.2.2.7.1 (Status and Management). Most of the physical and biological features are generally not applicable to the Study Area since they occur within the riverine habitat of the species. However, vessel noise would not affect any of the physical and biological features that do occur in the Study Area, including abundant prey items within marine habitats and safe and unobstructed migratory pathways between riverine, estuarine, and marine habitats.

Designated critical habitat for Atlantic salmon is restricted to rivers within Maine. All of the biological and physical features required by Atlantic salmon are only applicable to freshwater areas and would not be affected by vessel noise. Designated critical habitat for smalltooth sawfish is restricted to nearshore, shallow waters (less than 1 m) around the tip of Florida and does not overlap areas where vessels are operated.

Pursuant to the ESA, sound produced by vessel movement during training activities, as described under Alternative 1, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Sound produced by vessel movement during training activities, as described under Alternative 1, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta ray and oceanic whitetip sharks. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

Impacts from Vessel Noise under Alternative 1 for Testing Activities

As discussed in Chapter 2 (Description of the Proposed Action and Alternatives) and Section 3.0.3.3.1.4 (Vessel Noise), proposed testing activities under Alternative 1 include vessel movements in many events. Testing activities within the Study Area typically consist of a single vessel involved in unit-level activity for a few hours, one or two small boats conducting testing, or during a larger training event. Navy vessel traffic could occur anywhere within the Study Area, primarily concentrated within the Jacksonville and Virginia Capes Range Complexes; the Northeast Range Complexes and adjacent inland waters, especially near the Naval Underwater Warfare Center Newport Testing Range; and in the Gulf of Mexico, especially in areas near Naval Surface Warfare Center, Panama City Division Testing Range (Mintz, 2012).

Impacts on fishes due to vessel noise sound are expected to be limited to minor behavioral responses, short-term physiological stress, and short periods of masking; and, long-term consequences for populations would not be expected. Predicted impacts on ESA-listed fish species and designated critical habitat would not be discernible from those described above under Section 3.6.3.1.5.2 (Impacts from Vessel Noise Under Alternative 1 for Training Activities).

Pursuant to the ESA, sound produced by vessel movement during testing activities, as described under Alternative 2, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Sound produced by vessel movement during training activities, as described under Alternative 2, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta ray and oceanic whitetip sharks. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

3.6.3.1.5.3 Impacts from Vessel Noise under Alternative 2

Impacts from Vessel Noise under Alternative 2 for Training Activities

Proposed Training Activities under Alternative 2 that involve vessel movement slightly increase from Training Activities proposed under Alternative 1, but the locations, types, and severity of impacts would not be discernible from those described above under Section 3.6.3.1.5.2 (Impacts from Vessel Noise Under Alternative 1 for Training Activities).

Pursuant to the ESA, sound produced by vessel movement during training activities, as described under Alternative 2, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Sound produced by vessel movement during training activities, as described under Alternative 2, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta ray and oceanic whitetip sharks.

Impacts from Vessel Noise under Alternative 2 for Testing Activities

Proposed Testing Activities under Alternative 2 that involve vessel movement slightly increase from Testing Activities proposed under Alternative 1, but the locations, types, and severity of impacts would not be discernible from those described above Section 3.6.3.1.5.2 (Impacts from Vessel Noise Under Alternative 1 for Testing Activities).

Pursuant to the ESA, sound produced by vessel movement during testing activities, as described under Alternative 2, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Sound produced by vessel movement during training activities, as described under Alternative 2, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta ray and oceanic whitetip sharks.

3.6.3.1.5.4 Impacts from Vessel Noise under the No Action Alternative

Impacts from Vessel Noise under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various acoustic stressors (e.g., vessel noise) would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment either would remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.1.6 Impacts from Aircraft Noise

Fishes may be exposed to aircraft-generated overflight noise throughout the Study Area. A detailed description of the acoustic characteristics and typical sound produced by aircraft overflights are in Section 3.0.3.3 (Identifying Stressors for Analysis). Most of these sounds would be concentrated around airbases and fixed ranges within each of the range complexes. Aircraft noise could also occur in the waters immediately surrounding aircraft carriers at sea during takeoff and landing.

Aircraft produce extensive airborne noise from either turbofan or turbojet engines. A severe but infrequent type of aircraft noise is the sonic boom, produced when the aircraft exceeds the speed of sound. Rotary wing aircraft (helicopters) produce low-frequency sound and vibration (Pepper et al., 2003). Aircraft would pass quickly overhead and rotary-wing aircraft (e.g., helicopters) may hover for a few minutes at a time over the ocean. Aircraft overflights have the potential to affect surface waters and, therefore, to expose fish occupying those upper portions of the water column to sound.

Fish may be exposed to fixed-wing or rotary-wing aircraft-generated noise wherever aircraft overflights occur; however, sound is primarily transferred into the water from air in a narrow cone under the aircraft. Fish would have to be at or near the surface at the time of an overflight to be exposed to appreciable sound levels. Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors. These factors are discussed in detail in Appendix D (Acoustic and Explosives Concepts).

As discussed in Section 3.6.3.1.1.1 (Injury) and Section 3.6.3.1.1.2 (Hearing Loss), direct injury and hearing loss in fishes because of exposure to aircraft overflight noise is highly unlikely to occur. Sounds from aircraft noise, including occasional sonic booms, lack the amplitude or duration to cause injury or hearing loss in fishes underwater (see Section 3.6.3.1, Acoustic Stressors). Due to the brief and dispersed nature of aircraft overflights, the risk of masking is very low. If masking occurred, it would only be during periods of time where a fish is at the surface while a hovering helicopter is directly overhead.

Fixed- and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area. Fishes within close proximity to the activity and closer to the surface would have a higher probability of detecting these sounds although exposure to aircraft overflight noise would likely only last while the object is directly overhead. Training and testing events involving overflight noise are widely dispersed throughout the Study Area.

3.6.3.1.6.1 Methods for Analyzing Impacts from Aircraft Noise

The impacts on fishes due to exposure to aircraft noise are analyzed qualitatively by comparing reported observations under specific conditions as discussed in Section 3.6.3.1.1 (Background) to the conditions which fish may be exposed to during proposed Navy activities.

3.6.3.1.6.2 Impacts from Aircraft Noise under Alternative 1

Impacts from Aircraft Noise under Alternative 1 for Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives) and Section 3.0.3.3.1.5 (Aircraft Noise), training activities under Alternative 1 include fixed- and rotary-wing aircraft overflights. Aircraft flights during training would be most concentrated within the offshore waters of the Virginia Capes, Navy Cherry Point, Jacksonville, and Key West Range Complexes. In addition, aircraft noise could also be concentrated aboard aircraft carriers where flight takeoffs and landings occur at sea. The use of aircrafts during training activities, primarily helicopters, would also occur within several inshore water locations, but would be concentrated within the James Rivers and tributaries; Lower Chesapeake Bay; Kings Bay, Georgia; and Mayport and St. Johns River, Florida. Helicopters use the shortest route available and do not fly adjacent to the coastline when flying to the training and testing areas. Takeoffs and landings would occur on vessels at sea would occur at unspecified locations throughout the Study Area. A detailed description of aircraft noise as a stressor is provided in Section 3.0.3.3.1.5 (Aircraft Noise).

In most cases, exposure of fishes to fixed-wing aircraft presence and noise would be brief as the aircraft quickly passes overhead. Fishes would have to be at or near the surface at the time of an overflight to be exposed to appreciable sound levels. Due to the low sound levels in water, it is unlikely that fishes would respond to most fixed-wing aircraft or transiting helicopters. Because most overflight exposure would be brief and aircraft noise would be at low received levels, only startle reactions, if any, are expected in response to low altitude flights. Similarly, the brief duration of most overflight exposures would limit any potential for masking of relevant sounds.

Daytime and nighttime activities involving helicopters may occur for extended periods of time, up to a couple of hours in some areas. During these activities, helicopters would typically transit throughout an area but could also hover over the water. Longer activity durations and periods of time where helicopters hover may increase the potential for behavioral reactions, startle reactions, masking, and physiological stress. Low-altitude flights of helicopters during some activities, which often occur under 100 ft. altitude, may elicit a stronger startle response due to the proximity of a helicopter to the water; the slower airspeed and longer exposure duration; and the downdraft created by a helicopter's rotor.

If fish were to respond to aircraft noise, only short-term behavioral or physiological reactions (e.g., avoidance and increased heart rate) would be expected. Therefore, long-term consequences for individuals would be unlikely and long-term consequences for populations are not expected.

Each ESA-listed species within the Study Area could be exposed to aircraft overflight noise. However, due to the small area within which sound could potentially enter the water and the extremely brief window the sound could be present, exposures of ESA-listed fishes to aircraft noise would be extremely rare and in the event that they did occur, would be very brief (seconds). Likewise, although some portions of the Study Area overlap designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, aircraft noise would not affect critical habitat or any of the physical or biological features.

Pursuant to the ESA, sound produced by aircraft overflights during training activities, as described under Alternative 1, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. Sound produced by aircraft overflights during training activities, as described under Alternative 1, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta rays and oceanic whitetip sharks. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

Impacts from Aircraft Noise under Alternative 1 for Testing Activities

As discussed in Chapter 2 (Description of the Proposed Action and Alternatives) and Section 3.0.3.3.1.5 (Aircraft Noise), testing activities under Alternative 1 include fixed- and rotary-wing aircraft overflights. Testing activities with aircraft would be most concentrated within the offshore waters of the Northeast, Navy Cherry Point, Virginia Capes, and Jacksonville Range Complexes. Proposed testing activities under Alternative 1 that involve aircraft differ in number and location from training activities under Alternative 1; however, the types and severity of impacts would not be discernible from those described above under Section 3.6.3.1.6.2 (Impacts from Aircraft Noise Under Alternative 1 for Training Activities).

Each ESA-listed species within the Study Area could be exposed to aircraft overflight noise. However, due to the small area within which sound could potentially enter the water and the extremely brief window the sound could be present, exposures of ESA-listed fishes to aircraft noise would be rare and in the event that they did occur, would be very brief (seconds). Likewise, although some portions of the Study Area overlap designated critical habitat Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, aircraft noise would not affect critical habitat or any of the physical or biological features.

Pursuant to the ESA, sound produced by aircraft overflights during testing activities, as described under Alternative 1, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. Sound produced by aircraft overflights during testing activities, as described under Alternative 1, may affect may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta rays and oceanic whitetip sharks. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

3.6.3.1.6.3 Impacts from Aircraft Noise under Alternative 2

Impacts from Aircraft Noise under Alternative 2 for Training Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), and Section 3.0.3.3.1.5 (Aircraft Noise), training activities under Alternative 2 include a minor increase in the number of events that involve aircraft as compared to Alternative 1; however, the training locations, types of aircraft, and severity of predicted impacts would not be discernible from those described above under Section 3.6.3.1.6.2 (Impacts from Aircraft Noise Under Alternative 1 for Training Activities).

Pursuant to the ESA, sound produced by aircraft overflights during training activities, as described under Alternative 2, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. Sound produced by aircraft overflights during training activities, as described under Alternative 2, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta rays and oceanic whitetip sharks.

Impacts from Aircraft Noise under Alternative 2 for Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), and Section 3.0.3.3.1.5 (Aircraft Noise), testing activities under Alternative 2 include a minor increase in the number of events that involve aircraft noise as compared to Alternative 1; however, the testing locations, types of aircraft, and severity of predicted impacts would not be discernible from those described above in Section 3.6.3.1.6.2 (Impacts from Aircraft Noise Under Alternative 1 for Testing Activities).

Pursuant to the ESA, sound produced by aircraft overflights during testing activities, as described under Alternative 2, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. Sound produced by aircraft overflights during testing activities, as described under Alternative 2, may affect may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta rays and oceanic whitetip sharks.

3.6.3.1.6.4 Impacts from Aircraft Noise under the No Action Alternative

Impacts from Aircraft Noise under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various acoustic stressors (e.g., aircraft overflight noise) would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment either would remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.1.7 Impacts from Weapons Noise

Fishes could be exposed to noise from weapons firing, launch, flight downrange, and from the impact of non-explosive munitions on the water's surface. A detailed description of the acoustic characteristics of weapons noise is in Section 3.0.3.3.1.6 (Weapon Noise). Reactions by fishes to these specific stressors have not been recorded; however, fishes would be expected to react to weapons noise, as they would other transient sounds (Section 3.6.3.1.1.5, Behavioral Reactions).

3.6.3.1.7.1 Methods for Analyzing Impacts from Weapons Noise

The impacts on fishes due to exposure to weapons noise are analyzed qualitatively by comparing reported observations under specific conditions as discussed in section 3.6.3.1.1 (Background) to the conditions which fish may be exposed to during proposed Navy activities.

3.6.3.1.7.2 Impacts from Weapons Noise under Alternative 1

Impacts from Weapons Noise under Alternative 1 for Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), training activities under Alternative 1 include activities that produce in-water sound from weapons firing, launch, flight downrange, and non-explosive practice munitions impact with the water's surface. Training activities could occur throughout the Study Area but would be concentrated in the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes, with fewer events in the Northeast, Key West, and Gulf of Mexico Range Complexes. Most activities involving large-caliber naval gunfire or the launching of targets, missiles, bombs, or other munitions are conducted more than 12 NM from shore. Impacts from training activities would be highly localized and concentrated in space and duration.

Mortality, injury, hearing loss and masking in fishes because of exposure to weapons noise is highly unlikely to occur. Sound from these sources lack the duration and high intensity to cause injury or hearing loss. Therefore, injury and hearing loss is not discussed further in this analysis. Due to the brief and dispersed nature of weapons noise, masking is also unlikely and not discussed further in this analysis. However, potential impacts considered are short-term behavioral or physiological reactions (e.g., swimming away and increased heart rate).

Animals at the surface of the water, in a narrow footprint under a weapons trajectory, could be exposed to naval gunfire sound and may exhibit brief behavioral reactions such as startle reactions or avoidance, or no reaction at all. Due to the short-term, transient nature of gunfire activities, animals may be exposed to multiple shots within a few seconds, but are unlikely to be exposed multiple times within a short period (minutes or hours). Behavioral reactions would likely be short term (minutes) and are unlikely to lead to substantial costs or long-term consequences for individuals or populations.

Sound due to missile and target launches is typically at a maximum during initiation of the booster rocket and rapidly fades as the missile or target travels downrange. Many missiles and targets are launched from aircraft, which would produce minimal sound in the water due to the altitude of the aircraft at launch. Behavioral reactions would likely be short term (minutes) and are unlikely to lead to long-term consequences for individuals or populations.

As discussed in Section 3.0.3.3.1.6 (Weapon Noise), any objects that are dropped and impact the water with great force could produce a loud broadband sound at the water's surface. Large-caliber non-explosive projectiles, non-explosive bombs, and intact missiles and targets could produce a large impulse upon impact with the water surface (McLennan, 1997). Fishes within a few meters could experience some temporary hearing loss, although the probability is low of the non-explosive munitions landing within this range while a fish is near the surface. Animals within the area may hear the impact of object on the surface of the water and would likely alert, dive, or avoid the immediate area. Impact noise would not be expected to induce significant behavioral reactions from fishes, and long-term consequences for individuals and populations are unlikely.

As discussed previously (Section 3.6.2.1.3, Hearing and Vocalization), all ESA-listed fish species that occur in the Study Area are capable of detecting weapons noise but not all species occur in areas where weapons noise is present. Nassau grouper and shortnose sturgeon will not encounter weapons noise as they typically are found along the seafloor and smalltooth sawfish will not encounter weapons noise due to a lack in habitat overlap (i.e., they are largely confined to rivers and estuaries). Scalloped hammerhead sharks, and Gulf and Atlantic sturgeon could occur in areas associated with weapons noise however, these species don't typically swim near the surface at sea, therefore decreasing the likelihood of exposure. Atlantic salmon, giant manta ray and oceanic white tip sharks could be exposed to weapons noise. In particular, oceanic whitetip sharks in deeper waters spend much of their time at the surface, potentially increasing the risk of exposure. However, most species that occur within 12 NM of the shore would have a lower probability of encountering large caliber activities. ESA-listed fishes that are exposed to weapons noise may exhibit minor behavioral reactions or physiological stress. Due to the short-term, transient nature of weapons noise, fish are unlikely to be exposed multiple times within a short period. Physiological stress and behavioral reactions would likely be short term (seconds to minutes) and substantive costs or long-term consequences for individuals or populations would not be expected.

Proposed training activities that produce weapons noise largely occur greater than 12 NM from shore. Designated critical habitat for Gulf sturgeon only overlaps the nearshore portion of the Panama City OPAREA and the Naval Surface Warfare Center, Panama City Division Testing Range. A map of critical habitat is available in Section 3.6.2.2.7.1 (Status and Management). Most of the physical and biological features are generally not applicable to the Study Area since they occur within the riverine habitat of the species. Those that may occur within the Study Area include abundant prey items within marine habitats and safe and unobstructed migratory pathways between riverine, estuarine and marine habitats. However, weapons noise would not affect any of the physical and biological features that do occur in the Study Area.

Designated critical habitat for Atlantic salmon and Atlantic sturgeon is restricted to rivers within Maine or are within estuarine and river systems, respectively. Likewise, designated critical habitat for smalltooth sawfish is restricted to nearshore, shallow waters (less than 1 m) around the tip of Florida. Designated critical habitat for these three species does not overlap areas where weapons are used (typically greater than 12 NM from shore).

Pursuant to the ESA, weapons noise produced during training activities, as described under Alternative 1, will have no effect on ESA-listed shortnose sturgeon, smalltooth sawfish or Nassau grouper, or designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. Weapons noise produced during training activities, as described under Alternative 1, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, giant manta rays and oceanic whitetip sharks. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

Impacts from Weapons Noise under Alternative 1 for Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), testing activities under Alternative 1 include activities that produce weapons noise. Testing activities could occur in the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes, with fewer events in the Northeast, Key West, and Gulf of Mexico Range Complexes. Activities could also occur in the Naval Surface Warfare Center Panama Canal Testing Range. Most activities involving large-caliber naval gunfire or the launching of targets, missiles, bombs, or other munitions are conducted more than 12 NM from shore.

Proposed testing activities under Alternative 1 differ in number and location from training activities under Alternative 1; however, the types and severity of impacts would not be discernible from those described above for Impacts from Weapons Noise under Alternative 1 for Training Activities. Impacts on fish due to weapons noise are expected to be limited to short-term, minor behavioral responses and physiological stress; and, long-term consequences for an individual, and therefore populations, would not be expected.

As discussed previously (Section 3.6.2.1.3, Hearing and Vocalization), all ESA-listed fish species that occur in the Study Area are capable of detecting weapons noise but not all species occur in areas where weapons noise is present. Shortnose sturgeon, smalltooth sawfish, and Nassau grouper would not likely encounter weapon noise. Scalloped hammerhead sharks, and Gulf and Atlantic sturgeon could occur in areas associated with weapons noise however, these species don't typically swim near the surface at sea, therefore decreasing the likelihood of exposure. Atlantic salmon, giant manta ray and oceanic white tip sharks could be exposed to weapons noise. Most species that occur within 12 NM of the shore would have a lower probability of encountering these activities. ESA-listed fishes that are exposed to weapons noise may exhibit minor behavioral reactions or brief physiological stress. Due to the short-term, transient nature of weapons noise, fish are unlikely to be exposed multiple times within a short period. Physiological stress and behavioral reactions would likely be short term (minutes) and substantive costs or long-term consequences for individuals or populations would not be expected.

Proposed training activities that produce weapons noise largely occur greater than 12 NM from shore but could potentially occur in the Panama City OPAREA and the Naval Surface Warfare Center Panama City Testing Range and may overlap designated critical habitat for Gulf sturgeon. A map of critical habitat is available in Section 3.6.2.2.7.1 (Status and Management). Most of the physical and biological features are generally not applicable to the Study Area since they occur within the riverine habitat of the species. Those that may occur within the Study Area include abundant prey items within marine habitats and safe and unobstructed migratory pathways between riverine, estuarine and marine habitats. However, weapons noise would not affect any of the physical and biological features that do occur in the Study Area.

Designated critical habitat for Atlantic salmon and Atlantic sturgeon is restricted to rivers within Maine or are within estuarine and river systems, respectively. Likewise, designated critical habitat for smalltooth sawfish is restricted to nearshore, shallow waters (less than 1 m) around the tip of Florida. Designated critical habitat for these three species does not overlap areas where weapons are used (typically greater than 12 NM from shore).

Pursuant to the ESA, weapons noise produced during testing activities, as described under Alternative 1, will have no effect on ESA-listed shortnose sturgeon, smalltooth sawfish, Nassau grouper, or designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. Weapons noise produced during testing activities, as described under Alternative 1, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, giant manta rays and oceanic whitetip shark. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

3.6.3.1.7.3 Impacts from Weapons Noise under Alternative 2

Impacts from Weapons Noise under Alternative 2 for Training Activities

Proposed training activities under Alternative 2 that produce weapons noise differ in number and location from training activities under Alternative 1; however, the types and severity of impacts would not be discernible from those described above under Section 3.6.3.1.7.2 (Impacts from Weapons Noise Under Alternative 1 for Training Activities). Impacts on fishes due to weapons noise are expected to be limited to minor behavioral responses, short-term physiological stress, and short periods of masking; furthermore, long-term consequences for an individual, and therefore populations, would not be expected.

Pursuant to the ESA, weapons noise produced during training activities, as described under Alternative 2, will have no effect on ESA-listed shortnose sturgeon, smalltooth sawfish or Nassau grouper, or designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. Weapons noise produced during training activities, as described under Alternative 2, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, giant manta rays and oceanic whitetip sharks.

Impacts from Weapons Noise under Alternative 2 for Testing Activities

Proposed testing activities under Alternative 2 that produce weapons noise differ in number and location from testing activities under Alternative 1; however, the types and severity of impacts would not be discernible from those described above under Section 3.6.3.1.7.2 (Impacts from Weapons Noise Under Alternative 1 for Testing Activities). Impacts on fishes due to weapons noise are expected to be limited to minor behavioral responses, short-term physiological stress, and short periods of masking; and, long-term consequences for an individual, and therefore populations, would not be expected.

Pursuant to the ESA, weapons noise produced during testing activities, as described under Alternative 2, will have no effect on ESA-listed shortnose sturgeon, smalltooth sawfish, Nassau grouper, or designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. Weapons noise produced during testing activities, as described under Alternative 2, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, giant manta rays and oceanic whitetip shark.

3.6.3.1.7.4 Impacts from Weapons Noise under the No Action Alternative

Impacts from Weapons Noise under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various acoustic stressors (e.g., weapons noise) would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment either would remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.2 Explosive Stressors

Explosions in the water or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. However, unlike acoustic stressors, explosives release energy at a high rate producing a shock wave that can be injurious and even deadly. Therefore, explosive impacts on fishes are discussed separately from other acoustic stressors, even though the analysis of explosive impacts will in part rely on data from fishes exposed to impulsive sources where appropriate.

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

The ways in which an explosive exposure could result in immediate effects or lead to long-term consequences for an animal are explained in Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) and the below background section follows that framework. The following Background section discusses what is currently known about effects of explosives on fishes.

3.6.3.2.1 Background

The effects of explosions on fishes have been studied and reviewed by numerous authors (Keevin & Hempen, 1997; O'Keeffe, 1984; O'Keeffe & Young, 1984; Popper et al., 2014). A summary of the literature related to each type of effect forms the basis for analyzing the potential effects from Navy activities. The sections below include a survey and synthesis of best-available-science published in peer-reviewed journals, technical reports, and other scientific sources pertinent to impacts on fishes potentially resulting from Navy training and testing activities. Fishes could be exposed to a range of impacts depending on the explosive source and context of the exposure. In addition to acoustic impacts including temporary or permanent hearing loss, auditory masking, physiological stress, or changes in behavior, potential impacts from an explosive exposure can include non-lethal injury and mortality.

3.6.3.2.1.1 Injury

The blast wave from an in-water explosion is lethal to fishes at close range, causing massive organ and tissue damage (Keevin & Hempen, 1997). At greater distance from the detonation point, the extent of mortality or injury depends on a number of factors including fish size, body shape, depth, physical condition of the fish, and perhaps most importantly, the presence of a swim bladder (Keevin & Hempen, 1997; Wright, 1982; Yelverton et al., 1975; Yelverton & Richmond, 1981). At the same distance from the source, larger fishes are generally less susceptible to death or injury, elongated forms that are round in cross-section are less at risk than deep-bodied forms, and fishes oriented sideways to the blast suffer the greatest impact (Edds-Walton & Finneran, 2006; O'Keeffe, 1984; O'Keeffe & Young, 1984; Wiley et al., 1981; Yelverton et al., 1975). Species with a swim bladder are much more susceptible to blast injury from explosives than fishes without them (Gaspin, 1975; Gaspin et al., 1976; Goertner et al., 1994).

If a fish is close to an explosive detonation, the exposure to rapidly changing high pressure levels can cause barotrauma. Barotrauma is injury due to a sudden difference in pressure between an air space inside the body and the surrounding water and tissues. Rapid compression followed by rapid expansion of airspaces, such as the swim bladder, can damage surrounding tissues and result in the rupture of the airspace itself. The swim bladder is the primary site of damage from explosives (Wright, 1982; Yelverton et al., 1975). Gas-filled swim bladders resonate at different frequencies than surrounding tissue and can be torn by rapid oscillation between high- and low-pressure waves (Goertner, 1978). Swim bladders are a characteristic of most bony fishes with the notable exception of flatfishes (e.g., halibut). Sharks and rays are examples of fishes without a swim bladder. Small airspaces, such as micro-bubbles that may be present in gill structures, could also be susceptible to oscillation when exposed to the rapid pressure increases caused by an explosion. This may have caused the bleeding observed on gill structures of some fish exposed to explosions (Goertner et al., 1994). Sudden very high pressures can also cause damage at tissue interfaces due to the way pressure waves travel differently through tissues with different densities. Rapidly oscillating pressure waves might rupture the kidney, liver, spleen, and sinus and cause venous hemorrhaging (Keevin & Hempen, 1997).

Several studies have exposed fish to explosives and examined various metrics in relation to injury susceptibility. Sverdrup (1994) exposed Atlantic salmon (1 to 1.5 kg [2 to 3 lb.]) in a laboratory setting to repeated shock pressures of around 2 megapascals (300 pounds per square inch) without any immediate or delayed mortality after a week. Hubbs and Rechnitzer (1952) showed that fish with swim bladders exposed to explosive shock fronts (the near-instantaneous rise to peak pressure) were more susceptible to injury when several feet below the water surface than near the bottom. When near the surface, the fish began to exhibit injuries around peak pressure exposures of 40 to 70 pounds per square inch. However, near the bottom (all water depths were less than 100 ft.) fish exposed to pressures over twice as high exhibited no sign of injury. Yelverton et al. (1975) similarly found that peak pressure was not correlated to injury susceptibility. Yelverton et al. (1975) instead found that injury susceptibility of swim bladder fish at shallow depths (10 ft. or less) was correlated to the metric of positive impulse (Pa-s), which takes into account both the positive peak pressure and the duration of the positive pressure exposure, and the fish mass, with smaller fish being more susceptible.

Gaspin et al. (1976) exposed multiple species of fish with a swim bladder, placed at varying depths, to explosive blasts of varying size and depth. Goertner (1978) and Wiley (1981) developed a swim bladder oscillation model, which showed that the severity of injury observed in those tests could be correlated to the extent of swim bladder expansion and contraction predicted to have been induced by exposure to the explosive blasts. Per this model, the degree of swim bladder oscillation is affected by ambient pressure (i.e., depth of fish), peak pressure of the explosive, duration of the pressure exposure, and exposure to surface rarefaction (negative pressure) waves. The maximum potential for injury is predicted to occur where the surface reflected rarefaction (negative) pressure wave arrives coincident with the moment of maximum compression of the swim bladder caused by exposure to the direct positive blast pressure wave, resulting in a subsequent maximum expansion of the swim bladder. Goertner (1978) and Wiley et al. (1981) found that their swim bladder oscillation model explained the injury data in the Yelverton et al. (1975) exposure study and their impulse parameter was applicable only to fishes at shallow enough depths to experience less than one swim bladder oscillation before being exposed to the following surface rarefaction wave.

O’Keeffe (1984) provides calculations and contour plots that allow estimation of the range to potential effects of in-water explosions on fish possessing swim bladders using the damage prediction model developed by Goertner (1978). O’Keeffe’s (1984) parameters include the charge weight, depth of burst, and the size and depth of the fish, but the estimated ranges do not take into account unique propagation environments that could reduce or increase the range to effect. The 10 percent mortality range shown below in Table 3.6-12 is the maximum horizontal range predicted by O'Keeffe (1984) for 10 percent of fish suffering injuries that are expected to not be survivable (e.g., damaged swim bladder or severe hemorrhaging). Fish at greater depths and near the surface are predicted to be less likely to be injured because geometries of the exposures would limit the amplitude of swim bladder oscillations.

Table 3.6-12: Range to Effect from In-water Explosions for Fishes with a Swim Bladder

Weight of Pentolite (lb.) [NEW, lb.][1]	*Depth of Explosion (ft.) [m]*	*10% Mortality Maximum Range (ft.) [m]*		
		1 oz. Fish	*1 lb. Fish*	*30 lb. Fish*
10 [13]	10 [3]	530 [162]	315 [96]	165 [50]
	50 [15]	705 [214]	425 [130]	260 [79]
	200 [61]	905 [276]	505 [154]	290 [88]
100 [130]	10 [3]	985 [300]	600 [183]	330 [101]
	50 [15]	1,235 [376]	865 [264]	590 [180]
	200 [61]	1,340 [408]	1,225 [373]	725 [221]
1,000 [1,300]	10 [3]	1,465 [447]	1,130 [344]	630 [192]
	50 [15]	2,255 [687]	1,655 [504]	1,130 [344]
	200 [61]	2,870 [875]	2,390 [728]	1,555 [474]
10,000 [13,000]	10 [3]	2,490 [759]	1,920 [585]	1,155 [352]
	50 [15]	4,090 [1,247]	2,885 [879]	2,350 [716]
	200 [61]	5,555 [1,693]	4,153 [1,266]	3,090 [942]

[1]Explosive weights of pentolite converted to net explosive weight using the peak pressure parameters in Swisdak (1978). lb. = pounds, NEW = net explosive weight, oz. = ounce.
Source: O'Keeffe (1984)

In contrast to fish with swim bladders, fishes without swim bladders have been shown to be more resilient to explosives (Gaspin, 1975; Gaspin et al., 1976; Goertner et al., 1994). For example, some small (average 116 mm length; approximately 1 oz.) hogchokers (*Trinectes maculatus*) exposed less than 5 ft. from a 10-lb. pentolite charge immediately survived the exposure with slight to moderate injuries and only a small number of fish were immediately killed; however, most of the fish at this close range did suffer moderate to severe injuries, typically of the gills or around the otolithic structures (Goertner et al., 1994).

Studies that have documented caged fishes killed during planned in-water explosions indicate that most fish that die do so within one to four hours, and almost all die within a day (Yelverton et al., 1975). Mortality in free-swimming (uncaged) fishes may be higher due to increased susceptibility to predation. Fitch and Young (1948) found that the type of free-swimming fish killed changed when blasting was repeated at the same location within 24 hours of previous blasting. They observed that most fish killed on the second day were scavengers, presumably attracted by the victims of the previous day's blasts.

Fitch and Young (1948) also investigated whether a significant portion of fish killed would have sunk and not been observed at the surface. Comparisons of the numbers of fish observed dead at the surface and at the bottom in the same affected area after an explosion showed that fish found dead on the bottom comprised less than 10 percent of the total observed mortality. Gitschlag et al. (2000) conducted a more detailed study of both floating fishes and those that were sinking or lying on the bottom after explosive removal of nine oil platforms in the northern Gulf of Mexico. Results were highly variable. They found that 3 to 87 percent (46 percent average) of the red snapper killed during a blast might float to the surface. Currents, winds, and predation by seabirds or other fishes may be some of the reasons that the magnitude of fish mortality may not have been accurately captured.

There have been few studies of the impact of underwater explosives on early life stages of fish (eggs, larvae, juveniles). Fitch and Young (1948) reported mortality of larval anchovies exposed to underwater blasts off California. Nix and Chapman (1985) found that anchovy and smelt larvae died following the detonation of buried charges. Similar to adult fishes, the presence of a swim bladder contributes to shock wave-induced internal damage in larval and juvenile fish (Settle et al., 2002). Explosive shock wave injury to internal organs of larval pinfish and spot exposed at shallow depths was documented by Settle et al. (2002) and Govoni et al. (2003; 2008) at impulse levels similar to those predicted by Yelverton et al. (1975) for very small fish. Settle et al. (2002) provide the lowest measured received level that injuries have been observed in larval fish. Researchers (Faulkner et al., 2006; Faulkner et al., 2008; Jensen, 2003) have suggested that egg mortality may be correlated with peak particle velocity exposure (i.e., the localized movement or shaking of water particles, as opposed to the velocity of the blast wave), although sufficient data from direct explosive exposures is not available.

Rapid pressure changes could cause mechanical damage to sensitive ear structures due to differential movements of the otolithic structures. Bleeding near otolithic structures was the most commonly observed injury in non-swim bladder fish exposed to a close explosive charge (Goertner et al., 1994). General research findings regarding injury in fishes due to exposure to other impulsive sound sources are discussed under Section 3.6.3.1.1.1 (Injury due to Impulsive Sound Sources). Results from other impulsive sound exposure studies, such as those for seismic air guns and impact pile driving, may be useful in interpreting effects where data are lacking for explosive sources. As summarized by the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), exposure to explosive energy poses the greatest potential threat for injury and mortality in marine fishes. However, thresholds for the onset of injury from exposure to explosives are not currently available and recommendations in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) only provide qualitative criteria for consideration. Therefore, available data from existing explosive studies are used to estimate a threshold to the onset of injury (see discussion below under Section 3.6.3.2.2.1, Methods for Analyzing Impacts from Explosives). In general, fishes with a swim bladder are more susceptible to injury than fishes without a swim bladder. The susceptibility also probably varies with size and depth of both the detonation and the fish. Fish larvae or juvenile fish may be more susceptible to injury from exposure to explosives.

3.6.3.2.1.2 Hearing Loss

There are no direct measurements of hearing loss in fishes due to exposure to explosive sources. The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds such as those produced by air guns. PTS in fish has not been known to occur in species tested to date and any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al., 2005; Popper et al., 2014; Smith et al., 2006).

As reviewed in Popper et al. (2014), fishes without a swim bladder, or fishes with a swim bladder not involved in hearing, would be less susceptible to hearing loss (i.e., TTS), even at higher level exposures. Fish with a swim bladder involved in hearing may be susceptible to TTS within very close ranges to an explosive. General research findings regarding TTS in fishes as well as findings specific to exposure to other impulsive sound sources are discussed in Section 3.6.3.2.1.2 (Hearing Loss).

3.6.3.2.1.3 Masking

Masking refers to the presence of a noise that interferes with a fish's ability to hear biologically important sounds including those produced by prey, predators, or other fish in the same species (Myrberg, 1980; Popper et al., 2003). This can take place whenever the noise level heard by a fish exceeds the level of a biologically relevant sound. As discussed in Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking may lead to a change in vocalizations or a change in behavior (e.g., cessation of foraging, leaving an area).

There are no direct observations of masking in fishes due to exposure to explosives. Popper et al. (2014) highlights a lack of data that exist for masking by explosives but suggests that the intermittent nature of explosions would result in very limited probability of any masking effects and, if masking occurred, it would only occur during the duration of the sound. General research findings regarding masking in fishes due to exposure to sound are discussed in detail in Section 3.6.3.1.1.3 (Masking). Potential masking from explosives is likely to be similar to masking studied for other impulsive sounds such as air guns.

3.6.3.2.1.4 Physiological Stress

Fishes naturally experience stress within their environment and as part of their life histories. The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction). Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on physiological stress and the framework used to analyze this potential impact.

Research on physiological stress in fishes due to exposure to explosive sources is limited. Sverdrup et al. (1994) studied levels of stress hormones in Atlantic salmon after exposure to multiple detonations in a laboratory setting. Increases in cortisol and adrenaline were observed following the exposure, with adrenaline values returning to within normal range within 24 hours. General research findings regarding physiological stress in fishes due to exposure to impulsive sources are discussed in detail in Section 3.6.3.1.1.4 (Physiological Stress). Generally, stress responses are more likely to occur in the presence of potentially threatening sound sources such as predator vocalizations or the sudden onset of impulsive signals. Stress responses may be brief (a few seconds to minutes) if the exposure is short or if fishes habituate or learn to tolerate the noise. It is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

3.6.3.2.1.5 Behavioral Reactions

As discussed in Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), any stimuli in the environment can cause a behavioral response in fishes, including sound and energy produced by explosions. Behavioral reactions of fishes to explosions have not been recorded. Behavioral reactions from explosive sounds are likely to be similar to reactions studied for other impulsive sounds such as those produced by air guns. Impulsive signals, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle or avoidance responses. General research findings regarding behavioral reactions from fishes due to exposure to impulsive sounds, such as those associated with explosions, are discussed in detail in Section 3.6.3.1.1.5 (Behavioral Reactions).

As summarized by the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), species may react differently to the same sound source depending on a number of variables, such as the animal's life stage or behavioral state (e.g., feeding, mating). Without data that are more specific it is assumed that fishes with similar hearing capabilities react similarly to all impulsive sounds outside or within the zone for hearing loss and injury. Observations of fish reactions to large-scale air gun surveys are informative, but not necessarily directly applicable to analyzing impacts from the short-term, intermittent use of all impulsive sources. Fish have a higher probability of reacting when closer to an impulsive sound source (within tens of meters), and a decreasing probability of reaction at increasing distances (Popper et al., 2014).

3.6.3.2.1.6 Long-term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. For additional information on the determination of long-term consequences, see Section 3.0.3.6.1 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could affect navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions, masking and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for fish species that live for multiple seasons or years. For example, a lost reproductive opportunity could be a measurable cost to the individual; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences.

3.6.3.2.2 Impacts from Explosives

Fishes could be exposed to energy and sound from underwater and in-air explosions associated with proposed activities. General categories and characteristics of explosives and the numbers and sizes of detonations proposed are described in Section 3.0.3.3.2 (Explosive Stressors). The activities analyzed in the EIS/OEIS that use explosives are also described in Appendix A (Navy Activity Descriptions).

As discussed throughout Section 3.6.3.2.1 (Background), sound and energy from in-water explosions are capable of causing mortality, injury, hearing loss, a behavioral response, masking, or physiological stress, depending on the level and duration of exposure. The death of an animal would eliminate future reproductive potential, which is considered in the analysis of potential long-term consequences to the population. Exposures that result in non-auditory injuries may limit an animal's ability to find food, communicate with other animals, or interpret the surrounding environment. Impairment of these abilities can decrease an individual's chance of survival or affect its ability to reproduce. Temporary threshold shift can also impair an animal's abilities, although the individual may recover quickly with little significant effect.

3.6.3.2.2.1 Methods for Analyzing Impacts from Explosives

The Navy performed a quantitative analysis to estimate range to effects for fishes exposed to in-water explosions during Navy training and testing activities. Inputs to the quantitative analysis included sound propagation modeling in the Navy's Acoustic Effects Model to the sound exposure criteria and thresholds presented below. Density data for fish species within the Study Area are not currently available; therefore, it is not possible to estimate the total number of individuals that may be affected by explosive activities.

__Criteria and Thresholds used to Estimate Impacts on Fishes from Explosives__

Mortality and Injury from Explosives

Criteria and thresholds to estimate impacts from sound and energy produced by explosive activities are presented below in Table 3.6-13).

Table 3.6-13. In order to estimate the longest range at which a fish may be killed or mortally injured, the Navy based the threshold for mortal injury on the lowest pressure that caused mortalities in the study by Hubbs and Rechnitzer (1952), consistent with the recommendation in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014). As shown in Section 3.6.3.2.1.1 (Injury), this threshold likely over-estimates the potential for mortal injury. The potential for mortal injury has been shown to be correlated to fish size, depth, and geometry of exposure, which are not accounted for by using a peak pressure threshold. However, until fish mortality models are developed that can reasonably consider these factors across multiple environments, use of the peak pressure threshold allows for a conservative estimate of maximum impact ranges.

Due to the lack of detailed data for onset of injury in fishes exposed to explosives, thresholds from impact pile driving exposures (Halvorsen et al., 2011; Halvorsen et al., 2012a; Halvorsen et al., 2012b) were used as a proxy for the analysis in the AFTT Draft EIS. Upon re-evaluation during consultation, it was decided that pile driving thresholds are too conservative and not appropriate to use in the analysis of explosive effects on fishes. Therefore, injury criteria were revised as follows.

Thresholds for the onset of injury from exposure to explosives are not currently available and recommendations in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) only provide qualitative criteria for consideration. Therefore, available data from existing explosive studies were reviewed to provide a conservative estimate for a threshold to the onset of injury (Gaspin, 1975; Gaspin et al., 1976; Govoni et al., 2003; Govoni et al., 2008; Hubbs & Rechnitzer, 1952; Settle et al., 2002; Yelverton et al., 1975). It is important to note that some of the available literature is not peer-reviewed and may have some caveats to consider when reviewing the data (e.g., issues with controls, limited details on injuries observed, etc.) but this information may still provide a better understanding of where injurious effects would begin to occur specific to explosive activities. The lowest thresholds at which injuries were observed in each study were recorded and compared for consideration in selecting criteria. As a conservative measure, the absolute lowest peak sound pressure level recorded that resulted in injury, observed in exposures of larval fishes to explosions (Settle et al., 2002), was selected to represent the threshold to injury (see Table 3.6-13).

Table 3.6-13: Sound Exposure Criteria for Mortality and Injury from Explosives

Fish Hearing Group	Onset of Mortality	Onset of Injury
	SPL_{peak}	SPL_{peak}
Fishes without a swim bladder	229	220
Fishes with a swim bladder not involved in hearing	229	220
Fishes with a swim bladder involved in hearing	229	220
Fishes with a swim bladder and high-frequency hearing	229	220

SPL_{peak} = Peak sound pressure level.

The injury threshold is consistent across all fish, regardless of hearing group, due to the lack of rigorous data for multiple species. It is important to note that these thresholds may be overly conservative as there is evidence that fishes exposed to higher thresholds than the those in Table 3.6-13 have shown no signs of injury (depending on variables such as the weight of the fish, size of the explosion, depth of the cage, etc.). It is likely that adult fishes and fishes without a swim bladder would be less susceptible to injury than more sensitive hearing groups and larval species.

The number of fish killed by an in-water explosion would depend on the population density near the blast, as well as factors discussed throughout Section 3.6.3.2.1.1 (Injury) such as net explosive weight, depth of the explosion, and fish size. For example, if an explosion occurred in the middle of a dense school of menhaden, herring, or other schooling fish, a large number of fish could be killed. However, the probability of this occurring is low based on the patchy distribution of dense schooling fish. Stunning from pressure waves could also temporarily immobilize fish, making them more susceptible to predation.

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

Hearing Loss from Explosives

Criteria and thresholds to estimate TTS from sound produced by explosive activities are presented below in Table 3.6-14. Direct (measured) TTS data from explosives are not available. Criteria used to define TTS from explosives is derived from data on fishes exposed to seismic air gun signals (Popper et al., 2005) as summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014). TTS has not been documented in fishes without a swim bladder from exposure to other impulsive sources (pile driving and air guns). Although it is possible that fishes without a swim bladder could receive TTS from exposure to explosives, fishes without a swim bladder are typically less susceptible to hearing impairment than fishes with a swim bladder. If TTS occurs in fishes without a swim bladder, it would likely occur within the range of injury, therefore no threshold for TTS are proposed. General research findings regarding hearing loss in fishes as well as findings specific to exposure to other impulsive sound sources are discussed in Section 3.6.3.1.1.2 (Hearing Loss due to Impulsive Sound Sources).

Table 3.6-14: Sound Exposure Criteria for Hearing Loss from Explosives

Fish Hearing Group	*TTS (SEL_{cum})*
Fishes without a swim bladder	NC
Fishes with a swim bladder not involved in hearing	> 186
Fishes with a swim bladder involved in hearing	186
Fishes with a swim bladder and high-frequency hearing	186

Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), NC = no criteria are reported, ">" indicates that the given effect would occur above the reported threshold.

As discussed in Section 3.6.3.2.1.2 (Hearing Loss), exposure to sound produced from seismic air guns at a cumulative sound exposure level of 186 dB re 1 μPa^2-s has resulted in TTS in fishes with a swim bladder involved in hearing (Popper et al., 2005). TTS has not occurred in fishes with a swim bladder not involved in hearing and would likely occur above the given threshold in Table 3.6-14.

3.6.3.2.2.2 Impact Ranges for Explosives

The following section provides estimated range to effects for fishes exposed to sound and energy produced by explosives. Ranges are calculated using criteria from Table 3.6-13 and Table 3.6-14 and the Navy Acoustic Effects Model. Fishes within these ranges would be predicted to receive the associated effect. Ranges may vary greatly depending on factors such as the cluster size, location, depth, and season of the activity.

Table 3.6-15 provides range to mortality and injury for all fishes. Only one table (Table 3.6-16) is provided for range to TTS for all fishes with a swim bladder. However, ranges to TTS for fishes with a swim bladder not involved in hearing would be shorter than those reported because this effect has not been observed from the designated threshold in Table 3.6-14.

3.6.3.2.2.3 Impacts from Explosives under Alternative 1

Impacts from Explosives under Alternative 1 for Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.3.3.2 (Explosive Stressors), and Appendix A (Navy Activity Descriptions), training activities under Alternative 1 would use underwater detonations and explosive munitions. Training activities involving explosions would be concentrated in the Virginia Capes Range Complex, followed in descending order of numbers of activities by Jacksonville, Navy Cherry Point, Gulf of Mexico, Northeast, and Key West Range Complexes, and the lower Chesapeake Bay, although training activities could occur anywhere within the Study Area. Activities that involve underwater detonations and explosive munitions typically occur more than 3 NM from shore however, some mine warfare and demolition activities could also occur in shallow water close to shore. In addition, the Navy will implement mitigation to avoid impacts from explosives on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources), which will consequently also help avoid potential impacts on fishes that shelter and feed on shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks.

Table 3.6-15: Range to Mortality and Injury for All Fishes from Explosives

Bin	Range to Effects (meters)	
	Onset of Mortality	Onset of Injury
	SPL_{peak}	SPL_{peak}
E1 (0.25 lb. NEW)	49 (40–80)	119 (75—220)
E2 (0.5 lb. NEW)	57 (50–70)	129 (80—230)
E3 (2.5 lb. NEW)	105 (70–220)	266 (110—800)
E4 (5 lb. NEW)	151 (140–370)	448 (340—1,275)
E5 (10 lb. NEW)	163 (90–330)	380 (140—875)
E6 (20 lb. NEW)	218 (120–1,275)	518 (210—1,775)
E7 (60 lb. NEW)	465 (380–525)	1,740 (1,275—2,025)
E8 (100 lb. NEW)	419 (160–1,275)	1,114 (330—3,275)
E9 (250 lb. NEW)	462 (280–550)	925 (500—3,775)
E10 (500 lb. NEW)	511 (240–925)	1,028 (480—5,275)
E11 (650 lb. NEW)	1,075 (625–2,775)	2,806 (1,275—7,525)
E12 (1,000 lb. NEW)	701 (360–1,025)	1,441 (675—4,775)
E16 (14,500 lb. NEW)	5,039 (1,775–8,025)	9,284 (3,775—15,025)
E17 (58,000 lb. NEW)	6,740 (2,775–11,525)	12,306 (6,775—19,275)

Notes: SPL_{peak} = Peak sound pressure level. Range to effects represents modeled predictions in different areas and seasons within the Study Area. Each cell contains the estimated average, minimum and maximum range to the specified effect.

Table 3.6-16: Range to TTS for Fishes with a Swim Bladder from Explosives

Bin	*Cluster Size*	*Range to Effects (meters)*
		TTS[1]
		SEL_{cum}
E1 (0.25 lb. NEW)	1	< 52 (45–85)
	100	< 471 (180–1,275)
E2 (0.5 lb. NEW)	1	< 92 (55–170)
E3 (2.5 lb. NEW)	1	< 129 (75–260)
	50	< 830 (240–2,525)
E4 (5 lb. NEW)	1	< 432 (150–1,275)
E5 (10 lb. NEW)	1	< 198 (100–490)
	25	< 755 (260–2,775)
E6 (20 lb. NEW)	1	< 339 (170–1,275)
E7 (60 lb. NEW)	1	< 1,504 (1,275–1,775)
E8 (100 lb. NEW)	1	< 784 (240–2,525)
E9 (250 lb. NEW)	1	< 683 (340–1,275)
E10 (500 lb. NEW)	1	< 860 (370–7,775)
E11 (650 lb. NEW)	1	< 3,152 (1,525–8,525)
E12 (1,000 lb. NEW)	1	< 1,084 (525–7,525)
E16 (14,500 lb. NEW)	1	< 14,863 (11,525–21,775)
E17 (58,000 lb. NEW)	1	< 26,240 (13,775–51,775)

Notes: SEL_{cum} = Cumulative sound exposure level, TTS = Temporary Threshold Shift, "<" indicates that the given effect would occur at distances less than the reported range(s). Range to effects represent modeled predictions in different areas and seasons within the Study Area. Each cell contains the estimated average, minimum and maximum range to the specified effect.

Sound and energy from explosions could result in mortality and injury, on average, for hundreds to even thousands of meters from some of the largest explosions. Exposure to explosions could also result in hearing loss in nearby fishes. The estimated range to each of these effects based on explosive bin size is provided in Table 3.6-15 and Table 3.6-16. Generally, explosives that belong to larger bins (with large net explosive weights) produce longer ranges within each effect category. However, some ranges vary depending upon a number of other factors (e.g., number of explosions in a single activity, depth of the charge, etc.). Fishes without a swim bladder, adult fishes, and larger species would generally be less susceptible to injury and mortality from sound and energy associated with explosive activities than small, juvenile or larval fishes. Fishes that experience hearing loss could miss opportunities to detect predators or prey, or show a reduction in interspecific communication.

If an individual fish were repeatedly exposed to sound and energy from in-water explosions that caused alterations in natural behavioral patterns or physiological stress, these impacts could lead to long-term consequences for the individual such as reduced survival, growth, or reproductive capacity. If detonations occurred close together (within a few seconds), there could be the potential for masking to occur but this would likely happen at farther distances from the source where individual detonations might sound more continuous. Training activities involving explosions are generally dispersed in space and time. Consequently, repeated exposure of individual fishes to sound and energy from in-water explosions over the course of a day or multiple days is not likely and most behavioral effects are expected to be short term (seconds or minutes) and localized. Exposure to multiple detonations over the course of a day would most likely lead to an alteration of natural behavior or the avoidance of that specific area.

As discussed previously in Section 3.6.2.1.3 (Hearing and Vocalization), all ESA-listed fish species that occur in the Study Area are capable of detecting sound produced by explosives. Atlantic salmon, Atlantic sturgeon, smalltooth sawfish, Gulf sturgeon, scalloped hammerhead sharks, Nassau grouper, giant manta rays and oceanic whitetip sharks may be exposed to sound and energy from explosives associated with training activities throughout the Study Area. Atlantic salmon occur in the Northeast Range Complex where relatively few explosive activities occur throughout a given year. Although they may be more likely to be exposed to detonations at the water's surface or throughout the water column, impacts, if they occur, would be infrequent due to the lack of overlap in habitat and activity areas. Atlantic sturgeon may be exposed throughout the year in the Northeast, Navy Cherry Point, and Jacksonville Range Complexes but in particular, may be more likely to be exposed to activities that occur in the Virginia Capes Range Complex and the lower Chesapeake Bay. Shortnose sturgeon are primarily restricted to inshore waters with only infrequent excursions into the marine environment and therefore are not likely to be exposed to sound and energy from explosives. Smalltooth sawfish and Gulf sturgeon may be exposed to sound and energy from explosions associated with training activities throughout the year in the Gulf of Mexico Range Complex or the Panama City OPAREA. In addition, smalltooth sawfish could also occur in the Jacksonville and Key West Range Complex. Known habitat for the Central and Southwest Distinct Population Segment of scalloped hammerhead shark only overlaps with a small southeastern portion of the Study Area, so the likelihood of exposure would be rare. Nassau grouper may be exposed to training activities throughout the year in the southern portions of the Jacksonville Range Complex, as well as the Key West and Gulf of Mexico Range Complexes. Giant manta ray and oceanic whitetip sharks could be exposed in offshore areas throughout the Study Area.

Proposed training activities involving the use of explosives overlap designated critical habitat for Gulf sturgeon within one mile of the coastline in the eastern Gulf of Mexico as discussed in Section

3.6.2.2.7.1 (Status and Management). Most of the physical and biological features are generally not applicable to the Study Area since they occur within the riverine habitat of the species. However, part of the physical and biological features for Gulf sturgeon critical habitat includes abundant prey items (e.g., amphipods, lancelets, polychaetes, gastropods, ghost shrimp, isopods, molluscs, and crustaceans) within estuarine and marine habitats and substrates. The use of explosives within the critical habitat may affect a small number of prey items.

Designated critical habitat for Atlantic salmon and Atlantic sturgeon is restricted to rivers within Maine or are within estuarine and river systems, respectively. Likewise, designated critical habitat for smalltooth sawfish is restricted to nearshore, shallow waters (less than 1 m) around the tip of Florida. Explosives are typically detonated 3 NM offshore and do not overlap designated critical habitat designated for any of these species.

Pursuant to the ESA, the use of explosives during training activities, as described under Alternative 1, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon or smalltooth sawfish. The use of explosives during training activities, as described under Alternative 1, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta ray, oceanic whitetip sharks, and designated critical habitat for Gulf sturgeon. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

Impacts from Explosives under Alternative 1 for Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.3.3.2 (Explosive Stressors), and Appendix A (Navy Activity Descriptions), testing activities under Alternative 1 would involve underwater detonations and explosive munitions. Testing activities would be conducted, in descending order, in the Virginia Capes, Jacksonville, Northeast, Gulf of Mexico, Key West, and Navy Cherry Point Range Complexes, as well as the Naval Surface Warfare Center, Panama City Testing Range. Very few activities would be conducted in the Naval Undersea Warfare Center Division, Newport Testing Range, and the Naval Surface Warfare Center Carderock Division, South Florida Ocean Measurement Facility Testing Range. Small Ship Shock Trials could take place any season within the deep offshore water of the Virginia Capes Range Complex or in the spring, summer or fall within the Jacksonville Range Complex and would occur up to three times over a five-year period. The Large Ship Shock Trial could take place in the Jacksonville Range Complex during the spring, summer, or fall and during any season within the deep offshore water of the Virginia Capes Range Complex or within the Gulf of Mexico. The Large Ship Shock Trial would occur once over five years. Testing activities using explosives do not normally occur within 3 NM of shore; the exception is the designated underwater detonation area near Naval Surface Warfare Center, Panama City Division Testing Range, which is nearshore, partially within the surf zone. Although there is the potential for larger ranges to mortality or injury due to Ship Shock trials, proposed testing activities that involve explosives under Alternative 1 would differ in number and location from training activities under Alternative 1; however, the types and severity of impacts would not be discernible from those described above in Section 3.6.3.2.2.3 (Impacts from Explosives Under Alternative 1 for Training Activities).

To avoid potential impacts, the Navy will implement mitigation that includes ceasing ship shock trial explosive detonations if a large school of fish is observed in the mitigation zone, and seasonal mitigation for line charge testing specific to Gulf Sturgeon migrations in the Naval Surface Warfare Center, Panama City Division Testing Range, as discussed in Section 5.3.3, Explosive Stressors. In addition to procedural mitigation, the Navy will implement mitigation to avoid impacts from explosives on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources). The mitigation areas will further avoid potential impacts on fishes that shelter and feed on shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks.

As discussed previously in Section 3.6.2.1.3 (Hearing and Vocalization), all ESA-listed fish species that occur in the Study Area are capable of detecting sound produced by explosives. Atlantic salmon, Atlantic sturgeon, shortnose sturgeon, smalltooth sawfish, Gulf sturgeon, Nassau grouper, giant manta rays and oceanic whitetip sharks may be exposed to sound and energy from explosives associated with testing activities throughout the Study Area. Known habitat for the Central and Southwest Distinct Population Segment of scalloped hammerhead shark only overlaps with a small southern portion of the Study Area, but would not occur in range complexes where explosives are used during testing activities.

Atlantic salmon occur in the Northeast Range Complex where relatively few explosive activities occur throughout a given year. Although they may be more likely to be exposed to detonations at the water's surface or throughout the water column, impacts, if they occur, would be infrequent due to the lack of overlap in habitat and activity areas. Atlantic sturgeon may be exposed throughout the year in the Northeast, Navy Cherry Point, and Jacksonville Range Complexes and the NUWC Newport Testing Range but are more likely to be exposed to activities that occur in the Virginia Capes Range Complex and the lower Chesapeake Bay. Shortnose sturgeon would not likely be exposed to sound and energy from explosives associated with testing activities, including ship shock trials, as they are primarily restricted to inshore waters (rivers and estuaries) with only infrequent excursions into the marine environment. Smalltooth sawfish and Gulf sturgeon may be exposed to sound and energy from explosive activities associated with testing activities throughout the year in the Gulf of Mexico Range Complex and the Naval Surface Warfare Center, Panama City Division Testing Range. In addition, smalltooth sawfish could also occur in the southern portions of the Jacksonville Range Complex and the Key West Range Complexes. Nassau grouper may be exposed to testing activities throughout the year in the southern portion of the Jacksonville Range Complex and in the Key West and Gulf of Mexico Range Complexes, and specifically in the Naval Surface Warfare Center, Panama City Division Testing Range. Giant manta ray and oceanic whitetip sharks could be exposed in offshore areas throughout the Study Area.

To avoid potential impacts during one activity that occurs close to shore in Gulf sturgeon habitat (line charge testing), the Navy will implement mitigation that includes avoiding line charge testing in nearshore waters in the Naval Surface Warfare Center, Panama City Division Testing Range (except within the designated location on Santa Rosa Island) between October and March. The mitigation would help avoid impacts from explosives during Gulf sturgeon migrations from the Gulf of Mexico winter and feeding grounds to the spring and summer natal (hatching) rivers (the Yellow, Choctawhatchee, and Apalachicola Rivers).

Designated critical habitat for Atlantic salmon is restricted to rivers within Maine. Likewise, designated critical habitat for smalltooth sawfish is restricted to nearshore, shallow waters (less than 1 m) around the tip of Florida and Atlantic sturgeon critical habitat are within estuarine and river systems. Explosives are typically detonated 3 NM offshore and do not overlap designated critical habitat designated for any of these species.

Proposed testing activities overlap designated critical habitat for Gulf sturgeon within one mile of the coastline in the eastern Gulf of Mexico as discussed in Section 3.6.2.2.7.1 (Status and Management). Most of the physical and biological features are generally not applicable to the Study Area since they occur within the riverine habitat of the species. However, part of the physical and biological features for Gulf sturgeon critical habitat includes abundant prey items (e.g., amphipods, lancelets, polychaetes, gastropods, ghost shrimp, isopods, molluscs, and crustaceans) within estuarine and marine habitats and substrates. The use of explosives within the critical habitat may affect a small number of prey items.

Pursuant to the ESA, the use of explosives during testing activities, as described under Alternative 1, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon and smalltooth sawfish. The use of explosives during testing activities, as described under Alternative 1, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, shortnose sturgeon, smalltooth sawfish, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, giant manta rays and oceanic whitetip sharks, and designated critical habitat for Gulf sturgeon. The Navy has consulted with the National Marine Fisheries Service as required by section 7(a)(2) of the ESA in that regard.

3.6.3.2.2.4 Impacts from Explosives under Alternative 2

Impacts from Explosives under Alternative 2 for Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.3.3.2 (Explosive Stressors), and Appendix A (Navy Activity Descriptions), training activities under Alternative 2 would be almost identical to those described under Alternative 1. The differences in the number of activities within each range complex across a year is nominal with only slight increases in activities in the Virginia Capes Range Complex across a five-year period; therefore, the locations, types, and severity of predicted impacts would not be discernible from those described above in Section 3.6.3.2.2.3 (Impacts from Explosives under Alternative 1 for Training Activities).

Pursuant to the ESA, the use of explosives during training activities, as described under Alternative 2, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon or smalltooth sawfish. The use of explosives during training activities, as described under Alternative 2, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, giant manta ray, oceanic whitetip sharks, and designated critical habitat for Gulf sturgeon.

Impacts from Explosives under Alternative 2 for Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), testing activities under Alternative 2 include activities that produce sound and energy from explosives. Testing activities under Alternative 2 would be almost identical to those described under Alternative 1. The differences in the number of activities across a year is nominal with only slight increases in activities in the Virginia Capes Range Complex and the Naval Surface Warfare Center, Panama City Testing Range across a five-year period; therefore the locations, types, and severity of predicted impacts would not be discernible from those described above in Section 3.6.3.2.2.3 (Impacts from Explosives under Alternative 1 for Testing Activities).

Pursuant to the ESA, the use of explosives during testing activities, as described under Alternative 2, will have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon and smalltooth sawfish. The use of explosives during testing activities, as described under Alternative 2, may affect ESA-listed Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, shortnose sturgeon, smalltooth sawfish, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, giant manta rays and oceanic whitetip sharks, and designated critical habitat for Gulf sturgeon.

3.6.3.2.2.5 Impacts from Explosives under the No Action Alternative

Impacts from Explosives under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various explosive stressors (e.g., explosive shock wave and sound; explosive fragments) would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment either would remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.3 Energy Stressors

This section analyzes the potential impacts of the various types of energy stressors that can occur during training and testing activities within the Study Area. This section includes analysis of the potential impacts from (1) in-water and in-air electromagnetic devices and (2) high energy lasers.

3.6.3.3.1 Impacts from In-Water Electromagnetic Devices

Several different electromagnetic devices are used during training and testing activities. A discussion of the characteristics of energy introduced into the water through naval training and testing activities and the relative magnitude and location of these activities is presented in Section 3.0.3.3.3.1 (In-Water Electromagnetic Devices), while Table B-1 and Table B-2 (Appendix B, Activity Stressor Matrices) list the activities that use the devices.

A comprehensive review of information regarding the sensitivity of marine organisms to electric and magnetic impulses is presented in (Bureau of Ocean Energy Management, 2011). The synthesis of available data and information contained in this report suggests that while many fish species (particularly elasmobranchs) are sensitive to electromagnetic fields (Hore, 2012), further investigation is necessary to understand the physiological response and magnitude of the potential impacts. Most examinations of electromagnetic fields on marine fishes have focused on buried undersea cables associated with offshore wind farms in European waters (Boehlert & Gill, 2010; Gill, 2005; Ohman et al., 2007).

Many fish groups including lampreys, elasmobranchs, sturgeon, eels, marine catfish, salmonids, stargazers, tuna, and others, have an acute sensitivity to electrical fields, known as electroreception (Bullock et al., 1983; Helfman et al., 2009). Fishes likely use the same sensory organs (e.g., lateral line system particularly around the head) for electroreception and also for detecting sounds. Some species such as sharks such as the scalloped hammerhead have small pores near the nostrils, around the head and on the underside of the snout, or rostrum called ampullae of Lorenzini to detect the electromagnetic signature of their prey. Each ESA-listed fish species has some level of electroreception, but elasmobranchs (including sawfishes) are more sensitive than the others. Electroreceptors are thought to aid in navigation, orientation, and migration of sharks and rays (Kalmijn, 2000). In elasmobranchs, behavioral and physiological response to electromagnetic stimulus varies by species and age, and appears to be related to foraging behavior (Rigg et al., 2009). Many elasmobranchs respond physiologically to electric fields of 10 nanovolts per cm and behaviorally at 5 nanovolts per cm (Collin & Whitehead, 2004), while Kajiura & Holland (2002) showed juvenile scalloped hammerhead sharks detected and behaviorally responded to electric fields of less than 1 nanovolt per cm.

There are two general types of electroreceptor organs in fishes (Helfman et al., 2009). Ampullary receptors, located in recesses in the skin, are connected to the surface by a canal filled with a conductive gel and are sensitive to electric fields of low-frequency (<0.1 to 25 Hz). Tuberous receptors are located in depressions of the epidermis, are covered with loosely packed epithelial cells, and detect higher-frequency electric fields (50 Hz to > 2 kHz). They are typically found in fishes that use electric organs to produce their own electric fields. The distribution of electroreceptors on the head of these fishes, especially around the mouth (e.g., along the rostrum of sawfishes), suggests that these sensory organs may be used in foraging. Additionally, some researchers hypothesize that the electroreceptors aid in social communication (Collin & Whitehead, 2004).

Electromagnetic sensitivities of the Gulf, Atlantic, and shortnose sturgeon have not been heavily studied; however, the presence of electroreceptive ampullae in all sturgeon strongly supports the assertion that they are sensitive to electromagnetic energy (Bouyoucos et al., 2014). The ampullae of some fishes are sensitive to low frequencies (less than 0.1 to 25 Hz) of electrical energy (Helfman et al., 2009), which may be of physical or biological origin, such as muscle contractions. A recent study on juvenile Atlantic sturgeon showed a behavioral avoidance of electropositive metals when food was present (Bouyoucos et al., 2014). Zhang et al. (2012) studied electroreception on Siberian sturgeon (*Acipenser baerii*) and suggested that electroreception plays a role in the feeding behavior of most sturgeon species.

While elasmobranchs and other fishes can sense the level of the earth's electromagnetic field, the potential impacts on fishes resulting from changes in the strength or orientation of the background field are not well understood. When the electromagnetic field is enhanced or altered, sensitive fishes may experience an interruption or disturbance in normal sensory perception. Research on the electrosensitivity of sharks indicates that some species respond to electrical impulses with an apparent avoidance reaction (Helfman et al., 2009; Kalmijn, 2000). This avoidance response has been exploited as a shark deterrent, to repel sharks from areas of overlap with human activity (Marcotte & Lowe, 2008). A recent study on cat sharks (*Scyliorhinus canicula*) demonstrated that sharks may show habituation to electrical fields over short-term exposures (Kimber et al., 2014). Other studies suggest that sharks are attracted to electromagnetic sources when conditions in the water hinder their other senses such as sight and hearing. This attraction to electromagnetic sources helps sharks to find prey when in these low sensory conditions (Fields, 2007).

The mechanism for direct sensing of magnetic fields is unknown; however, the presence of magnetite (a magnetic mineral) in the tissues of some fishes such as tunas and salmon, or other sensory systems such as the inner ear and the lateral line system may be responsible for electromagnetic reception (Helfman et al., 2009). Magnetite of biogenic origins has been documented in the lateral line of the European eel (*Anguilla anguilla*), a close relative of the American eel; both species occur in the Study Area (Moore & Riley, 2009). These species undergo long-distance migrations from natal waters of the Sargasso Sea (North Atlantic Subtropical Gyre) to freshwater habitats in Europe and North America (Helfman et al., 2009), where they mature and then return as adults to the Sargasso Sea to spawn. Some species of salmon, tuna, and stargazers have likewise been shown to respond to magnetic fields and may also contain magnetite in their tissues (Helfman et al., 2009).

Experiments with electromagnetic pulses can provide indirect evidence of the range of sensitivity of fishes to similar stimuli. Two studies reported that exposure to electromagnetic pulses do not have any effect on fishes (Hartwell et al., 1991; Nemeth & Hocutt, 1990). The observed 48-hour mortality of small estuarine fishes (e.g., sheepshead minnow, mummichog, Atlantic menhaden, striped bass, Atlantic silverside, fourspine stickleback, and rainwater killifish) exposed to electromagnetic pulses of 100—200 kilovolts per meter (10 nanoseconds per pulse) from distances greater than 50 m was not statistically different than the control group (Hartwell et al., 1991; Nemeth & Hocutt, 1990). During a study of

Atlantic menhaden, there were no statistical differences in swimming speed and direction (toward or away from the electromagnetic pulse source) between a group of individuals exposed to electromagnetic pulses and the control group (Hartwell et al., 1991; Nemeth & Hocutt, 1990).

Electromagnetic sensitivity in some marine fishes (e.g., salmonids) is already well-developed at early life stages (Ohman et al., 2007); however, most of the limited research that has occurred focuses on adults. A laboratory study on Atlantic salmon showed no behavioral changes for adults and post-smolts passing through an area with a 50 Hz magnetic field activated (Armstrong et al., 2015). Some species appear to be attracted to undersea cables, while others show avoidance (Ohman et al., 2007). Under controlled laboratory conditions, the scalloped hammerhead (*Sphyrna lewini*) and sandbar shark (*Carcharhinus plumbeus*) exhibited altered swimming and feeding behaviors in response to very weak electric fields (less than 1 nanovolt per cm) (Kajiura & Holland, 2002). In a test of sensitivity to fixed magnets, five Pacific sharks were shown to react to magnetic field strengths of 2,500 to 234,000 µT (microtesla) at distances ranging between 0.26 and 0.58 m and avoid the area (Rigg et al., 2009). A field trial in the Florida Keys demonstrated that southern stingrays (*Dasyatis americana*) and nurse sharks (*Ginglymostoma cirratum*) detected and avoided a fixed magnetic field producing a flux of 95,000 µT (O'Connell et al., 2010). A field study on white sharks (*Carcharodon carcharias*) in South Africa suggested behavioral changes in the sharks when approaching a towed prey item with an active electromagnetic field (Huveneers et al., 2013). No change was noticed in the sharks' behavior towards a static prey item. The maximum electromagnetic fields typically generated during Navy training and testing activities is approximately 2,300 µT.

Potential impacts of electromagnetic activity on adult fishes may not be relevant to early life stages (eggs, larvae, juveniles) due to ontogenic (lifestage-based) shifts in habitat utilization (Botsford et al., 2009; Sabates et al., 2007). Some skates and rays produce egg cases that lay on the bottom, while many neonate and adult sharks occur in the water column or near the water surface. Exposure of eggs and larvae (ichthyoplankton) to electromagnetic fields would be low since their distributions are extremely patchy. Early life history stages of ESA-listed sturgeon and Atlantic salmon occur in freshwater or estuarine habitats outside of the Study Area. Similarly, sawfish neonates and juveniles typically inhabit nearshore mangrove habitats, beyond the areas where in-water electromagnetic devices are used. For many sharks, skates, rays, and livebearers, the fecundity and natural mortality rates are much lower, and the exposure of the larger neonates and juveniles to electromagnetic energy would be similar across life stages for these species.

Based on current literature, only the fish groups identified above are capable of detecting electromagnetic fields (primarily elasmobranchs, sturgeon, salmonids, tuna, eels, and stargazers) and thus will be carried forward in this section. The remaining major fish groups from Table 3.6-2 will not be presented further. Aspects of electromagnetic stressors that are applicable to marine organisms in general are described in Section 3.0.3.6.2 (Conceptual Framework for Assessing Effects from Energy-Producing Activities).

3.6.3.3.1.1 Impacts from In-Water Electromagnetic Devices under Alternative 1

Impacts from In-Water Electromagnetic Devices under Alternative 1 for Training Activities

Under Alternative 1, training activities involving in-water electromagnetic devices occur in the Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Caribbean Sea, and Gulf of Mexico Large Marine Ecosystems—specifically within the Virginia Capes Range Complex, Navy Cherry Point Range Complex, Jacksonville Range Complex, Gulf of Mexico Range Complex, and within inshore waters in these areas.

Activities that use in-water electromagnetic devices would remain concentrated within the Virginia Capes Range Complex, accounting for 63 percent of the annual activities. Fish species that do not occur within these specified areas—including the ESA-listed Atlantic salmon, Nassau groupers, and Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark—would not be exposed to in-water electromagnetic devices. Species that do occur within the areas listed above—including the ESA-listed smalltooth sawfish, Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, giant manta rays, and oceanic whitetip sharks—would have the potential to be exposed to in-water electromagnetic devices.

Exposure is limited to those marine fish groups able to detect electromagnetic properties in the water column, as described in Section 3.6.2 (Affected Environment), such as elasmobranchs, sturgeon, tuna, salmon, eels, and stargazers (Bullock et al., 1983; Helfman et al., 2009). Fishes sensitive to electromagnetic fields (primarily elasmobranchs, sturgeon, salmonids, tuna, eels, and stargazers) may experience temporary disturbance of normal sensory perception during migratory or foraging movements, or they could experience avoidance or attraction reactions (Fields, 2007; Kalmijn, 2000), resulting in alterations of behavior and avoidance of normal foraging areas or migration routes. Exposure of electromagnetically sensitive fish species to electromagnetic activities has the potential to result in stress to the animal and may also elicit alterations in normal behavior patterns (e.g., swimming, feeding, resting, and spawning). Such effects may have the potential to disrupt long-term growth and survival of an individual. However, due to the temporary (hours) and isolated locations where in-water electromagnetic devices are used in the Study Area, the resulting stress on fishes is not likely to impact the health of resident or migratory populations. Likewise, some fish in the vicinity of training activities may react to in-water electromagnetic devices, but the signals are not widespread or frequent enough to alter behavior on a long-term basis. Any behavioral changes are not expected to have lasting effects on the survival, growth, recruitment, or reproduction of these marine fish groups at the population level.

Smalltooth sawfish, Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, oceanic whitetip sharks, and giant manta rays are the only ESA-listed fish species occurring in training areas that are known to be capable of detecting electromagnetic energy. Smalltooth sawfish could occur in the Jacksonville Range Complex, but any occurrences would be extremely rare (Florida Museum of Natural History, 2011). Atlantic sturgeon inhabit inshore and coastal waters, and therefore may encounter in-water electromagnetic devices used in training activities in bays and estuaries, like the lower Chesapeake Bay. Other locations include portions of the range complexes that lie over the Continental Shelf, overlapping the normal distribution of Atlantic sturgeon, shortnose sturgeon, and smalltooth sawfish. Oceanic whitetip sharks and giant manta rays are found in offshore waters and may encounter in-water electromagnetic devices used in training activities in those areas. Any behavioral changes are not expected to have lasting effects on the survival, growth, recruitment, or reproduction of fishes at the population level.

Training activities involving in-water electromagnetic devices may overlap with Gulf sturgeon critical habitat in the coastal portion of the Panama City OPAREA. In addition, the civilian port defense training activity may occur in St. Andrew Bay in areas designated as Gulf sturgeon critical habitat. However, the biological and physical features associated with the critical habitat designations would not be impacted by these activities. In addition, civilian port defense training activities in Wilmington (NC) and Delaware Bay (DE) and Savannah (GA) overlap with designated Atlantic sturgeon critical habitat in the Delaware

River and Savannah River, respectively. However, the biological and physical features associated with the designated critical habitats would not be impacted by the activities.

All of the biological and physical features required by Atlantic salmon are applicable to freshwater only and are outside the Study Area. Therefore, none of the electromagnetic stressors would affect Atlantic salmon critical habitat. The biological and physical features of critical habitat for smalltooth sawfish are red mangrove habitats and shallow marine waters of less than 1 m deep. Electromagnetic activities do not occur at these depths and thus would not overlap with smalltooth sawfish critical habitat.

The in-water electromagnetic devices used in training activities would not be anticipated to result in more than minimal impact on fishes as individuals or populations because of: (1) the relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m from the source), (2) the highly localized potential impact area, and (3) the limited and temporally distinct duration of the activities (hours). Some fishes could have a detectable response to electromagnetic exposure, but the fields generated are typically well below physiological and behavioral responses of magnetoreceptive fishes, and any impacts would be temporary with no anticipated impact on an individual's growth, survival, annual reproductive success, or lifetime reproductive success (i.e., fitness), or species recruitment, and are not expected to result in population-level impacts. Electromagnetic exposure of eggs and larvae of sensitive bony fishes would be low relative to their total ichthyoplankton biomass (Able & Fahay, 1998); therefore, potential impacts on recruitment would not be expected.

Pursuant to the ESA, the use of in-water electromagnetic devices during training activities, as described under Alternative 1, would have no effect on Atlantic salmon, Nassau grouper, and the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, and critical habitats designated for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Training activities under Alternative 1 involving the use of in-water electromagnetic devices may affect Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from In-Water Electromagnetic Devices under Alternative 1 for Testing Activities

Under Alternative 1, testing activities involving in-water electromagnetic devices occur in a number of areas, including Virginia Capes Range Complex, Navy Cherry Point Range Complex, Jacksonville Range Complex, Gulf of Mexico Range Complex, South Florida Ocean Measurement Facility, Naval Surface Warfare Center Panama City Testing Range, and within inshore waters (see Table 3.0-14 and Table 3.0-15). Atlantic salmon and scalloped hammerhead sharks belonging to the Central and Southwest Atlantic Distinct Population Segment do not occur within these specified areas and would not be exposed to in-water electromagnetic devices during testing activities.

ESA-listed species that occur within these areas, including Atlantic sturgeon, shortnose sturgeon smalltooth sawfish, Gulf sturgeon, Nassau grouper, scalloped hammerhead sharks, oceanic whitetip sharks, and giant manta rays would have the potential to be exposed to in-water electromagnetic devices.

Exposure is limited to those marine fish groups able to detect electromagnetic properties in the water column, as described in Section 3.6.2 (Affected Environment), such as elasmobranchs, sturgeon, tuna, salmon, eels, and stargazers (Bullock et al., 1983; Helfman et al., 2009). Two such species, the Atlantic torpedo ray (*Torpedo nobiliana*) and the lesser electric ray (*Narcine brasiliensis*) occur in the Naval

Surface Warfare Center, Panama City Division Testing Range, where a portion of the electromagnetic activities would be concentrated.

All of the ESA-listed fish species occurring in areas where testing occurs are capable of detecting electromagnetic energy, with the exception of Nassau grouper. Potential exposure to electromagnetic testing activities may occur in the offshore portions of the testing ranges that lie within the continental shelf, overlapping the normal distribution of Gulf sturgeon, Atlantic sturgeon, shortnose sturgeon, and smalltooth sawfish. Oceanic whitetip sharks and giant manta rays are found in offshore waters and may encounter in-water electromagnetic devices used in testing activities in those areas. Behavioral changes are not expected to have lasting effects on the survival, growth, recruitment, or reproduction of fish species.

Testing activities involving in-water electromagnetic devices may overlap with Gulf sturgeon critical habitat in the coastal waters of the Panama City OPAREA. However, the biological and physical features associated with the critical habitat designations would not be impacted by these activities. The use of electromagnetic devices during testing activities does not overlap with designated Atlantic sturgeon critical habitat.

All of critical habitat biological and physical features required by Atlantic salmon are applicable to freshwater only and are outside the Study Area. Therefore, none of the electromagnetic stressors would affect Atlantic salmon critical habitat. The biological and physical features for smalltooth sawfish are red mangrove habitats and shallow marine waters of less than 1 m deep. Electromagnetic activities do not occur at these depths and thus would not overlap with smalltooth sawfish critical habitat.

The in-water electromagnetic devices used in testing activities would not cause any risk to fish because of the: (1) relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m from the source), (2) highly localized potential impact area, and (3) limited and temporally distinct duration of the activities (hours). Fishes may have a detectable response to electromagnetic exposure, but would likely recover completely. Potential impacts of exposure to electromagnetic stressors are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

Pursuant to the ESA, the use of in-water electromagnetic devices during testing activities, as described under Alternative 1, would have no effect on Atlantic salmon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Testing activities under Alternative 1 involving the use of in-water electromagnetic devices may affect Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.3.1.2 Impacts from In-Water Electromagnetic Devices under Alternative 2

Impacts from In-Water Electromagnetic Devices under Alternative 2 for Training Activities

Because the locations, number of events, and potential effects associated with in-water electromagnetic devices would be the same under Alternatives 1 and 2, impacts experienced by fishes from in-water electromagnetic devices use under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of in-water electromagnetic devices during training activities, as described under Alternative 2, would have no effect on Atlantic salmon, Nassau grouper, and the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, and critical habitats designated for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Training activities under Alternative 2 involving the use of in-water electromagnetic devices may affect Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish.

Impacts from In-Water Electromagnetic Devices under Alternative 2 for Testing Activities

Because the locations, number of events, and potential effects associated with in-water electromagnetic devices would be the same under Alternatives 1 and 2, impacts experienced by fishes from in-water electromagnetic devices use under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of in-water electromagnetic devices during testing activities, as described under Alternative 2, would have no effect on Atlantic salmon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Testing activities under Alternative 2 involving the use of in-water electromagnetic devices may affect Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.3.1.3 Impacts from In-Water Electromagnetic Devices under the No Action Alternative

Impacts from In-Water Electromagnetic Devices under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Electromagnetic fields from towed devices or unmanned mine warfare systems would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.3.2 Impacts from In-Air Electromagnetic Devices

In-air electromagnetic stressors are not applicable to fishes because they are transmitted in the air and not underwater and will not be analyzed further in this section.

3.6.3.3.3 Impacts from High-Energy Lasers

This section analyzes the potential impacts of high energy lasers on fishes. As discussed in Section 3.0.3.3.3.3 (Lasers), high energy laser weapons are designed to disable surface targets, rendering them immobile. The primary impact from high-energy lasers would be from the laser beam striking the fish at or near the water's surface, which could result in injury or death.

Fish could be exposed to a laser only if the beam missed the target. Should the laser strike the sea surface, individual fish at or near the surface could be exposed. The potential for exposure to a high energy laser beam decreases as the water depth increases. Most fish are unlikely to be exposed to laser activities because they primarily occur more than a few meters below the sea surface.

3.6.3.3.3.1 Impacts from High-Energy Lasers under Alternative 1

Impacts from High-Energy Lasers under Alternative 1 for Training Activities

Under Alternative 1, training activities involving high-energy lasers only occur within the Virginia Capes and Jacksonville Range Complexes. Fish species in these areas that occur near the surface, such as oceanic whitetip sharks and giant manta rays, would have the potential to be exposed to high-energy lasers. Although occurring in areas of laser use, while in coastal and offshore waters, Atlantic sturgeon, shortnose sturgeon, and smalltooth sawfish typically occur in the lower depths of the water column or near the seafloor and would not be exposed. Atlantic salmon, Gulf sturgeon, Nassau grouper, and the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark do not occur in areas of laser use. In addition, the use of high energy lasers under Alternative 1 for training activities does not overlap with the designated critical habitat for any of the ESA-listed fish species.

Pursuant to the ESA, the use of high-energy lasers during training activities, as described under Alternative 1, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of high-energy lasers during training activities under Alternative 1 may affect giant manta rays and oceanic whitetip sharks. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from High-Energy Lasers under Alternative 1 for Testing Activities

Under Alternative 1, high-energy laser weapons would be used for testing activities in the AFTT Study Area, the Northeast U.S. Continental Shelf and Southeast U.S. Continental Shelf Large Marine Ecosystems and Gulf Stream Open Ocean Area (see Table 3.0-16). High-energy laser testing occurs at the highest frequency within the Virginia Capes Range Complex, but would also occur at the Northeast Range Complexes, Navy Cherry Point Range Complex, Jacksonville Range Complex, Key West Range Complex, Gulf of Mexico Range Complex, Naval Undersea Warfare Center Newport Testing Range, South Florida Ocean Measurement Facility, and Naval Surface Warfare Center Panama City Testing Range. Species that occur near the surface at these locations within these areas would have the potential to be exposed.

Some ESA-listed species such as Atlantic salmon, oceanic whitetip sharks, giant manta rays, and Central and Southwestern Atlantic Distinct Population Segment scalloped hammerhead sharks that are found in offshore locations and occur near the surface of the water column, may pose a higher risk of being exposed to high-energy lasers. Although occurring in areas of laser use, while in coastal and offshore waters, Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, smalltooth sawfish, and Nassau grouper typically occur in the lower depths of the water column or near the seafloor and would not be exposed. High-energy laser weapons tests would not overlap with critical habitat for Atlantic salmon, Atlantic sturgeon, smalltooth sawfish, or Gulf sturgeon

Fishes are unlikely to be exposed to high-energy lasers based on: (1) the relatively low number of events, (2) the very localized potential impact area of the laser beam, and (3) the temporary duration of potential impact (seconds).

Pursuant to the ESA, the use of high-energy lasers during testing activities, as described under Alternative 1, would have no effect on Atlantic sturgeon, Gulf sturgeon, Nassau grouper, shortnose sturgeon, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of high-energy lasers during testing activities under Alternative 1 may affect Atlantic salmon, giant manta rays, oceanic whitetip sharks, and the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.3.3.2 Impacts from High-Energy Lasers under Alternative 2

Impacts from High-Energy Lasers under Alternative 2 for Training Activities

Because activities under Alternative 2 occur at the same rate and frequency relative to Alternative 1, impacts experienced by fishes from high-energy laser use under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of high-energy lasers during training activities, as described under Alternative 2, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, the Central and Southwest Atlantic Distinct Population Segment of the scalloped hammerhead shark, shortnose sturgeon, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of high-energy lasers during training activities under Alternative 2 may affect giant manta rays and oceanic whitetip sharks.

Impacts from High-Energy Lasers under Alternative 2 for Testing Activities

Because activities under Alternative 2 occur at the same rate and frequency relative to Alternative 1, impacts experienced by fishes from high-energy laser use under Alternative 2 are the same as those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of high-energy lasers during testing activities, as described under Alternative 2, would have no effect on Atlantic sturgeon, Gulf sturgeon, Nassau grouper, shortnose sturgeon, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of high-energy lasers during testing activities under Alternative 2 may affect Atlantic salmon, giant manta rays, oceanic whitetip sharks, and the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks.

3.6.3.3.3.3 Impacts from High-Energy Lasers under the No Action Alternative

Impacts from High-Energy Lasers under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area and fishes would not be exposed to high-energy lasers. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.4 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance and potential for strike during training and testing activities within the Study Area from (1) vessels and in water devices, (2) military expended materials, including non-explosive practice munitions and fragments from high-explosive munitions, and (3) seafloor devices. A discussion of the relative magnitude and location of physical disturbance and strike stressors is presented in Section 3.0.3.3.4 (Physical Disturbance and

Strike Stressors), while Table B-1 and Table B-2 (Appendix B, Activity Stressor Matrices) list the activities that use the devices.

How a physical strike impacts a fish depends on the relative size of the object potentially striking the fish and the location of the fish in the water column. Before being struck by an object, Atlantic salmon for example, would sense a pressure wave through the water (Hawkins & Johnstone, 1978) and have the ability to swim away from the oncoming object. The movement generated by a large object moving through the water would simply displace small fishes in open water, such as Atlantic herring. Some fish might have time to detect the approaching object and swim away; others could be struck before they become aware of the object. An open-ocean fish that is displaced a small distance by movements from an object falling into the water nearby would likely continue on its original path as if nothing had happened. However, a bottom-dwelling fish near a sinking object would likely be disturbed, and may exhibit a general stress response, as described in Section 3.0.3.6 (Biological Resource Methods). As in all vertebrates, the function of the stress response in fish is to rapidly alter blood chemistry levels or ratios to prepare the fish to flee or fight (Helfman et al., 2009). This generally adaptive physiological response can become a liability to the fish if the stressor persists and the fish is not able to return to its baseline physiological state. When stressors are chronic, the fish may experience reduced growth, health, or survival (Wedemeyer et al., 1990). If the object hits the fish, direct injury (in addition to stress) or death may result.

The potential responses to a physical strike are varied, but include behavioral changes such as avoidance, altered swimming speed and direction, physiological stress, and physical injury or mortality. Despite their ability to detect approaching vessels using a combination of sensory cues (e.g., sight, hearing, and lateral line), larger slow-moving fishes (e.g., whale sharks [*Rhincodon typus*], basking sharks [*Cetorhinus maximus*], manta rays [*Manta* spp.), sturgeon [*Acipenser* spp.], and ocean sunfish) cannot avoid all collisions, with some collisions resulting in mortality (Balazik et al., 2012; Braun et al., 2015; Brown & Murphy, 2010; Couturier et al., 2012; Deakos et al., 2011; Foderaro, 2015; Germanov & Marshall, 2014; Graham et al., 2012; Miller & Klimovich, 2016; Ramirez-Macias et al., 2012; Rowat et al., 2007; Speed et al., 2008; Stevens, 2007). Many fishes respond by darting quickly away from the stimulus. Some other species may respond by freezing in place and adopting cryptic coloration, while still some other species may respond in an unpredictable manner. Regardless of the response, the individual must stop its current activity and divert its physiological and cognitive attention to responding to the stressor (Helfman et al., 2009). The energy costs of reacting to a stressor depend on the specific situation, but in all cases the caloric requirements of stress reactions reduce the amount of energy available to the fish for other functions, such as predator avoidance, reproduction, growth, and maintenance (Wedemeyer et al., 1990).

The ability of a fish to return to its previous activity following a physical strike (or near-miss resulting in a stress response) is a function of a variety of factors. Some fish species are more tolerant of stressors than others and become re-acclimated more easily. Within a species, the rate at which an individual recovers from a physical strike may be influenced by its age, sex, reproductive state, and general condition. A fish that has reacted to a sudden disturbance by swimming at burst speed would tire after only a few minutes; its blood hormone and sugar levels (cortisol and glucose) may not return to normal for up to, or longer than, 24 hours. During its recovery period, the fish would not be able to attain burst speeds and would be more vulnerable to predators (Wardle, 1986). If the individual were not able to regain a steady state following exposure to a physical stressor, it may suffer reduced immune function and even death (Wedemeyer et al., 1990).

Potential impacts of physical disturbance and strike to adults may be different than for other life stages (e.g., eggs, larvae, juveniles) because these life stages do not necessarily occur together in the same location (Botsford et al., 2009; Sabates et al., 2007), and because they have different response capabilities. The numbers of eggs and larvae exposed to vessel movements would be low relative to total ichthyoplankton biomass (Able & Fahay, 1998); therefore, measurable effects on fish recruitment would not be expected. Also, the early life stages of most marine fishes (excluding sharks and other livebearers) already have extremely high natural mortality rates (10 to 85 percent per day) from predation on these life stages (Helfman et al., 2009), and therefore, most eggs and larvae are not expected to survive to the next life stage.

3.6.3.4.1 Impacts from Vessels and In-Water Devices

Representative Navy vessel types, lengths, and speeds of vessels and in-water devices used in the Study Area is presented in Table 3.0-17 and Table 3.0-21. The number and location of activities, including vessels and in-water devices for each alternative is presented in Table 3.0-18 and Table 3.0-22, while Table B-1 (Appendix B, Activity Stressor Matrices) lists the activities that use the devices.

Vessels

Vessels do not normally collide with adult fishes, most of which can detect and avoid them. One study on Barents sea capelin (*Mallotus villosus*) behavioral responses to vessels showed that most adults exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jørgensen et al., 2004), reducing the potential for vessel strikes. Misund (1997) found that fishes, such as Polar cod (*Boreogadus saida*), haddock (*Melanogrammus aeglefinus*), jack mackerel (*Trachurus symmetricus*), sardine (*Sardina pilchardus*), herring, anchovy (*Engraulis ringens*), and capelin, that were ahead of a ship showed avoidance reactions and did so at ranges of 50 to 350 m. When the vessel passed over them, some fishes had sudden avoidance responses that included lateral avoidance or downward compression of the school. Conversely, Rostad et al. (2006) observed that some fishes are attracted to different types of vessels (e.g., research vessels, commercial vessels) of varying sizes, noise levels, and habitat locations. Fishes involved in that study included herring (*Clupea harengus*), sprat (*Sprattus sprattus*), and whitefish (*Merlangius merlangus*) (Rostad et al., 2006). Fish behavior in the vicinity of a vessel is therefore quite variable, depending on the type of fish, its life history stage, behavior, time of day, and the sound propagation characteristics of the water (Schwarz & Greer, 1984). Early life stages of most fishes could be displaced by vessels and not struck in the same manner as adults of larger species. However, a vessel's propeller movement or propeller wash could entrain early life stages. The low-frequency sounds of large vessels or accelerating small vessels caused avoidance responses among herring (Chapman & Hawkins, 1973), but avoidance ended within 10 seconds after the vessel departed.

There are a few notable exceptions to this assessment of potential vessel strike impacts on fish groups. Large slow-moving fishes such as whale sharks (Ramirez-Macias et al., 2012; Rowat et al., 2007; Speed et al., 2008; Stevens, 2007), basking sharks (Pacific Shark Research Center, 2017; The Shark Trust, 2017), manta rays (Braun et al., 2015; Couturier et al., 2012; Deakos et al., 2011; Germanov & Marshall, 2014; Graham et al., 2012; Miller & Klimovich, 2016), and sturgeon (Balazik et al., 2012; Brown & Murphy, 2010; Foderaro, 2015) may occur near the surface in open-ocean and coastal areas, thus making them more susceptible to ship strikes which may result in blunt trauma, lacerations, fin damage, or mortality. Stevens (2007) noted that increases in the numbers and sizes of shipping vessels in the modern cargo fleets make it difficult to gather strike-related mortality data for whale sharks because personnel on large ships are often unaware of collisions; therefore, the occurrence of vessel strikes is likely much higher than has been documented by the few studies that have been conducted. This holds true not just for whale sharks, but also for any of the aforementioned fish species.

In addition to whale sharks, Atlantic sturgeon have also been documented to be susceptible to vessel strikes. Brown and Murphy (2010) found that 28 deaths of Atlantic sturgeon in the Delaware Bay and the Delaware River were reported over the four-year period of 2005 to 2008. Of those, 50 percent were caused by vessel collisions, although the size and type of the vessels was unknown. An unknown number of additional sturgeon were likely struck by vessels and were not included in this total. Based on an egg-per-recruit analysis of the Delaware River population, the authors concluded that an annual mortality rate of 2.5 percent of the females could have adverse impacts on the population (Brown & Murphy, 2010). In Virginia, Balazik et al. (2012) investigated Atlantic sturgeon mortalities due to vessel strikes that occurred in upstream areas of the James River. Based on observations of fish implanted with acoustic transmitters, the authors concluded that when moving the tracked individuals occurred in water depths overlapping with the draft of ocean cargo vessels (about 23 ft.), but were rarely in depths overlapping the draft of tugboats and small recreational craft (about 3 to 7 ft.). However, as a result of the very small sample size (three fish), this conclusion bears little support. The fish were detected in the navigation channel of the river 69 percent of the time. More recently in New York, it was noted that over the latest three-year period (2012 through 2014), there were 76 known Atlantic sturgeon fatalities attributed to boat strikes around the Tappan Zee Bridge on the Hudson River, in addition to over two dozen more reported during the first six months of 2015 (Foderaro, 2015). This reflects a significant increase when compared to the previous three-year period (2009 through 2011) during which only six sturgeon fatalities were documented. Many have attributed this increase in sturgeon mortality to the increased boat traffic associated with the expansion of the Tappan Zee Bridge, which began in 2012. However, they may also, in part, be the result of an increased effort into monitoring for fish strandings. Regardless, it illustrates the level of susceptibility of Atlantic sturgeon to vessel strikes.

Based on the typical physiological responses described in Section 3.6.3.4 (Physical Disturbance and Strike Stressors), vessel movements are not expected to compromise the general health or condition of individual fishes, except for large slow-moving fishes such as whale sharks, basking sharks, manta rays, sturgeon, and ocean sunfish (Balazik et al., 2012; Brown & Murphy, 2010; Foderaro, 2015; Rowat et al., 2007; Speed et al., 2008; Stevens, 2007).

In-Water Devices

In-water devices do not normally collide with adult fishes, as most can detect and avoid them. Fish responses to in-water devices would be similar to those discussed above for vessels. Fishes would likely show varying behavioral avoidance responses to in-water devices. Early life stages of most fishes could be displaced by in-water devices and not struck in the same manner as adults of larger species. Because in-water devices are continuously moving, most fishes are expected to move away from it or to follow behind it.

3.6.3.4.1.1 Impacts from Vessels and In-Water Devices under Alternative 1

Impacts from Vessels and In-Water Devices under Alternative 1 for Training Activities

Section 3.0.3.3.4.1 (Vessels and In-Water Devices) provide estimates of relative vessel and in-water devices use and location for each of the alternatives. These estimates are based on the number of activities predicted for each alternative. While these estimates predict use, actual Navy vessel usage depends on military training and testing requirements, deployment schedules, annual budgets, and other unpredictable factors. Training concentrations mostly depend on locations of Navy shore installations and established training areas. The Navy's use of these areas has not appreciably changed in the last decade and are not expected to change in the foreseeable future. Under Alternative 1, the concentration of vessel movement and in-water device use and the manner in which the Navy trains would remain consistent with the range of variability observed over the last decade. As underwater technologies advance, it is likely that the frequency of in-water device use may increase. However, the Navy does not foresee any appreciable changes in the locations where in-water devices have been used over the last decade, and therefore the level at which strikes are expected to occur is likely to remain consistent with the previous decade.

Navy training vessel traffic could occur anywhere in the Study Area, but would especially be concentrated in Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes, as presented in Table 3.0-18. In addition, there are numerous areas within inshore waters where vessels during training activities would be concentrated, including the Lower Chesapeake Bay; James River and tributaries; Norfolk, VA; Mayport, FL; Groton, CT; and Narragansett, RI (see Table 3.0-19). Of particular importance would be inshore areas where activities involving large amounts of high-speed vessel movements occur, such as the Lower Chesapeake Bay; James River and tributaries; York River; Cooper River, SC; and Narragansett, RI (see Table 3.0-20). Navy training in-water device use could also take place anywhere in the Study Area, but primarily occurs in the Virginia Capes, Jacksonville, and Navy Cherry Point Range Complexes. A large number of activities involving in-water devices also occur in inshore waters, predominately in the Lower Chesapeake Bay; James River and tributaries; Mayport, FL; and Kings Bay, GA (see Table 3.0-23).

The risk of a strike from vessels and in-water devices such as a remotely operated vehicles, unmanned surface vehicles, unmanned underwater vehicles, motorized autonomous targets, or towed mine warfare devices used in training activities would be extremely low because (1) most fishes can detect and avoid vessel and in-water device movements; and (2) the types of fish that are likely to be exposed to vessel and in-water device strike are limited and occur in low concentrations where vessels and in-water devices are most frequently used. Potential impacts from exposure to vessels and in-water devices are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

As described above, the potential exception would be large, slow-moving fish species, such as Atlantic sturgeon, which are documented to be highly susceptible to vessel strikes and are concentrated in inshore areas where intense high speed vessel movement activities as part of the Proposed Action are common (see Table 3.0-20). Atlantic sturgeon may be susceptible to vessel strikes in these areas, including Lower Chesapeake Bay, James River and tributaries, York River, and Cooper River, resulting in potential injury or mortality. This species is most susceptible to vessel and in-water device strikes in these areas because all five distinct population segments congregate in large numbers in the lower Chesapeake Bay, all sturgeon belonging to two separate and genetically distinct spawning populations from the James River and the York River populations must pass through the Lower Chesapeake Bay on their way to and from their spawning grounds, and the York River spawning population is estimated to be very small (several hundred fish) and likely consists of higher numbers of males and relatively few females. As a result, even a loss of a couple of females to this spawning population could have long-term consequences. Gulf sturgeon, a congener of Atlantic sturgeon, are also likely susceptible to vessel and in-water device strikes.

Due to their preference for riverine habitats, absence from the Lower Chesapeake Bay and its tributaries, and close association to the seafloor, shortnose sturgeon are not considered to be highly susceptible to vessel and in-water device strikes, with only a few ship strike have been documented for this species (Shortnose Sturgeon Status Review Team, 2010). Likewise, smalltooth sawfish are typically found in shallow, coastal waters where training activities do not occur. When in deeper waters, smalltooth sawfish tend to remain along the seafloor. Nassau grouper are strongly associated with reef and live hard bottom seafloor habitats and, as such, would not be susceptible to vessel and in-water device use.

Giant manta rays in offshore areas may be susceptible to vessel strikes in those areas, as are the closely related reef manta ray (Braun et al., 2015; Couturier et al., 2012; Deakos et al., 2011; Germanov & Marshall, 2014; Graham et al., 2012; Miller & Klimovich, 2016). However, unlike the reef manta ray, the giant manta ray is typically found in low numbers and rarely aggregates.

As Atlantic salmon, scalloped hammerhead sharks, and oceanic whitetip sharks also typically occur within the upper water column or at the surface, there is the potential for an interaction to occur, though it is highly unlikely given their ability to detect and avoid vessel and in-water device movements.

Vessel and in-water device use during training activities potentially overlaps with designated critical habitat for Atlantic salmon, Gulf sturgeon, smalltooth sawfish and Atlantic sturgeon, but vessel and in-water device use would not impact any of the physical and biological features associated with critical habitat designations.

Pursuant to the ESA, the use of vessels and in-water devices during training activities, as described under Alternative 1, would have no effect on Nassau grouper, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Vessel and in-water device use during training activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, and shortnose sturgeon. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Vessels and In-Water Devices under Alternative 1 for Testing Activities

As indicated in Section 3.0.3.3.4.1 (Vessels and In-Water Devices), most of the testing activities involve vessel movements. However, the number of activities that include the vessel movement for testing is comparatively lower than the number of training activities. In addition, testing often occurs jointly with a training event, so it is likely that the testing activity would be conducted from 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, piers, range complexes, and testing ranges. Specifically, testing activities that include vessels would be conducted within the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes; the Naval Undersea Warfare Division, Newport Testing Range; South Florida Ocean Measurement Facility Testing Range; Naval Surface Warfare Center, Panama City Division Testing Range; as well as inshore waters within the AFTT Study Area. Testing activities involving the use of in-water devices would also occur in the AFTT Study Area at any time of year. Under Alternative 1, testing activities involving the use of in-water devices would be conducted throughout the AFTT Study Area, including the same areas where vessel movement is occurring (with the exception of inshore waters locations).

As previously discussed, with the exception of some large, slow-moving species that may occur at the surface, the risk of a strike from a vessel or in-water device used in testing activities would be extremely low because most fishes can detect and avoid in-water device movements, and exposure to vessels and in-water devices are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

As described above in the Alternative 1 training analysis, Atlantic sturgeon, Gulf sturgeon, and giant manta rays have been shown to be susceptible to vessel strikes. As Atlantic salmon, scalloped hammerhead sharks, and oceanic whitetip sharks also typically occur within the upper water column or at the surface, there is the potential for an interaction to occur, though it is highly unlikely given their ability to detect and avoid vessel and in-water device movements.

Due to their preference for riverine habitats, absence from the Lower Chesapeake Bay and its tributaries, and close association to the seafloor, shortnose sturgeon are susceptible to vessel and in-water device strikes, but the risk is low. As stated above, only a few ship strike have been documented for this species (Shortnose Sturgeon Status Review Team, 2010). Likewise, smalltooth sawfish are typically found in shallow, coastal waters where testing activities do not occur. When in deeper waters, smalltooth sawfish tend to remain along the seafloor. Nassau grouper are strongly associated with reef and live hardbottom seafloor habitats and, as such, would not be susceptible to vessel and in-water device use.

Vessel and in-water device use potentially overlaps with designated critical habitat for Atlantic salmon, Gulf sturgeon, smalltooth sawfish, and Atlantic sturgeon, but vessel and in-water device use would not impact any of the physical and biological features associated with critical habitat designations. Vessel and in-water device use in smalltooth sawfish critical habitat is extremely unlikely and would not affect the physical and biological identified for these habitats.

Pursuant to the ESA, the use of vessels and in-water devices during testing activities, as described under Alternative 1, would have no effect on Nassau grouper, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Vessel and in-water device use during testing activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, and shortnose sturgeon. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.4.1.2 Impacts from Vessels and In-Water Devices under Alternative 2

Impacts from Vessels and In-Water Devices under Alternative 2 for Training Activities

Activities under Alternative 2 would occur at a slightly higher rate and frequency relative to Alternative 1 for certain activities. Therefore, physical disturbance and strike stress experienced by fishes from vessel use and in-water devices under Alternative 2 are expected to be slightly increased in comparison to those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are slightly greater than they are for Alternative 1.

Pursuant to the ESA, the use of vessels and in-water devices during training activities, as described under Alternative 2, would have no effect on Nassau grouper, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Vessel and in-water device use during training activities under Alternative 2 may affect Atlantic salmon, Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, and shortnose sturgeon.

Impacts from Vessels and In-Water Devices under Alternative 2 for Testing Activities

Because testing activities under Alternative 2 would occur at the same rate and frequency relative to Alternative 1, physical disturbance and strike stress experienced by fishes from vessel use and in-water device under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of vessels and in-water devices during testing activities, as described under Alternative 2, would have no effect on Nassau grouper, smalltooth sawfish, and designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Vessel and in-water device use during testing activities under Alternative 2 may affect Atlantic salmon, Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, and shortnose sturgeon.

3.6.3.4.1.3 Impacts from Vessels and In-Water Devices under the No Action Alternative

Impacts from Vessels and In-Water Devices under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various physical strike stressors to fishes from vessels or in-water devices would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.4.2 Impacts from Aircraft and Aerial Targets

Aircraft and aerial targets stressors are not applicable to fishes because they are conducted in the air and not underwater and will not be analyzed further in this section.

3.6.3.4.3 Impacts from Military Expended Materials

Navy training and testing activities in the Study Area include firing a variety of weapons and employing a variety of explosive and non-explosive rounds including bombs; small-, medium-, and large-caliber projectiles; or sinking exercises with ship hulks. During these training and testing activities, various items may be introduced and expended into the marine environment and are referred to as military expended materials.

This section analyzes the disturbance or strike potential to fishes of the following categories of military expended materials: (1) non-explosive practice munitions, (2) fragments from high-explosive munitions, and (3) expended materials other than munitions, such as sonobuoys, ship hulks, and expendable targets. Section 3.0.3.3.4.2 (Military Expended Materials) provides information on the quantity and location where various types of military expended materials would occur under each alternative. Appendix F (Military Expended Materials and Direct Strike Impact Analyses) provides additional information on each military expended material proposed to be used, where it would be used, how many would be used, and the amount of area impacted by each material. Analysis of all potential impacts (disturbance, strike) of military expended materials on critical habitat is included in this section.

While disturbance or strike from any of these objects as they sink through the water column is possible, it is not very likely for most expended materials because the objects generally sink through the water slowly and can be avoided by most fishes. Therefore, with the exception of sinking exercises, the discussion of military expended materials strikes focuses on strikes at the surface or in the upper water column from fragments (of high-explosives) and projectiles because those items have a greater potential for a fish strike as they hit the water, before slowing down as they move through the water column.

Ship Hulk. During a sinking exercise, aircraft, ship, and submarine crews fire or drop munitions on a seaborne target, usually a clean deactivated ship (Section 3.2, Sediments and Water Quality), which is deliberately sunk using multiple weapon systems. A description of Sinking Exercises is presented in Appendix A (Navy Activity Descriptions). Sinking exercises occur in specific open ocean areas, outside of the coastal range complexes, in waters exceeding 3,000 m (9,842.5 ft.) in depth. Direct munitions strikes from the various weapons used in these exercises are a source of potential impact. However, these impacts are discussed for each of those weapons categories in this section and are not repeated in the respective sections. Therefore, the analysis of sinking exercises as a strike potential for benthic fishes is discussed in terms of the ship hulk landing on the seafloor.

Small-, Medium-, and Large-Caliber Projectiles. Various types of projectiles could cause a temporary (seconds), localized impact when they strike the surface of the water. Current Navy training and testing in the Study Area, such as gunnery exercises and testing events, include firing a variety of weapons and using a variety of non-explosive training and testing rounds, including 5-in. naval gun shells, and small-, medium-, and large-caliber projectiles. The larger-caliber projectiles are primarily used in the open ocean beyond 20 NM. Direct munitions strikes from firing weapons are potential stressors to fishes. There is a remote possibility that an individual fish at or near the surface may be struck directly if it is at the point of impact at the time of non-explosive practice munitions delivery. Expended rounds may strike the water surface with sufficient force to cause injury or mortality. However, limited fish species swim right at, or near, the surface of the water (e.g., with the exception of pelagic sharks, herring, salmonids, flying fishes, jacks, tuna, mackerels, billfishes, ocean sunfish, and other similar species).

Various projectiles would fall on soft or hard bottom habitats, where they could either become buried immediately in the sediments, or sit on the bottom for an extended time period. Most munitions would sink through the water column and come to rest on the seafloor, stirring up sediment and possibly inducing an alarm response, displacing, or injuring nearby fishes in extremely rare cases. Particular impacts on a given fish species would depend on the size and speed of the munitions, the water depth, the number of rounds delivered, the frequency of training and testing, and the sensitivity of the fish (U.S. Department of the Navy, 2013).

Bombs, Missiles, and Rockets. Direct munitions strikes from bombs, missiles, and rockets are potential stressors to fishes. Some individual fish at or near the surface may be struck directly if they are at the point of impact at the time of non-explosive munitions delivery. However, most missiles hit their target or are disabled before hitting the water. Thus, most of these missiles and aerial targets hit the water as fragments, which quickly dissipates their kinetic energy within a short distance of the surface. A limited number of fishes swim right at, or near, the surface of the water, as described for small-, medium-, and large-caliber projectiles.

Even though statistical modeling conducted for the Study Area (discussed in Appendix F, Military Expended Materials and Direct Strike Impact Analyses) indicates that the probability of military expended materials striking marine mammals or sea turtles is extremely low, modeling could not be conducted to estimate the probability of military expended material strikes on an individual fish. This is primarily due to the lack of fish density data available at the scale of a range complex or testing range.

In lieu of strike probability modeling, the number, size, and area of potential impact (or "footprints") of each type of military expended material is presented in Appendix F (Military Expended Materials and Direct Strike Impact Analyses).

The application of this type of footprint analysis to fish follows the notion that a fish occupying the impact area could be susceptible to potential impacts, either at the water surface (e.g., pelagic sharks, herring, salmonids, flying fishes, jacks, tuna, mackerels, billfishes, and ocean sunfish (Table 3.6-2) or as military expended material falls through the water column and settles to the bottom (e.g., flounders, skates, and other benthic fishes listed in Table 3.6-2). Furthermore, 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. Of that small portion, a small number of fishes at or near the surface (pelagic fishes) or near the bottom (benthic fishes) may be directly impacted if they are in the target area and near the expended item that hits the water surface (or bottom).

Propelled fragments are produced by an exploding bomb. Close to the explosion, fishes could potentially sustain injury or death from propelled fragments (Stuhmiller et al., 1991). However, studies of underwater bomb blasts show that fragments are large and decelerate rapidly (O'Keeffe & Young, 1984; Swisdak & Montanaro, 1992), posing little risk to marine organisms.

Fish disturbance or strike could result from bomb fragments (after explosion) falling through the water column in very small areas compared to the vast expanse of the testing ranges range complexes, or the remainder of the Study Area. The expected reaction of fishes exposed to military expended materials would be to immediately leave the area where bombing is occurring, thereby reducing the probability of a fish strike after the initial expended materials hit the water surface. When a disturbance of this type concludes, the area would be repopulated and the fish stock would rebound, with inconsequential impacts on the resource (Lundquist et al., 2010).

3.6.3.4.3.1 Impacts from Military Expended Materials under Alternative 1

Impacts from Military Expended Materials under Alternative 1 for Training Activities

As stated above, Section 3.0.3.3.4.2 (Military Expended Materials) provides information on the quantity and location where various types of military expended materials would occur under each alternative, while Appendix F (Military Expended Materials and Direct Strike Impact Analyses) has more information on where the military expended material would be used, how many would be used, and the amount of area impacted by each material.

Major fish groups identified in Table 3.6-2 that are particularly susceptible to military expended material strikes are those occurring at the surface, within the offshore and continental shelf portions of the range complexes (where the strike would occur). Those groups include pelagic sharks, herring, salmonids, flying fishes, jacks, tuna, mackerels, billfish, ocean sunfish, and other similar species (Table 3.6-2). Additionally, certain deep-sea fishes would be exposed to strike risk as a ship hulk, expended during a sinking exercise, settles to the seafloor. These groups include hagfish, dragonfish, lanternfishes, Aulopiformes, anglerfishes, and oarfishes.

Projectiles, bombs, missiles, rockets, and associated fragments have the potential to directly strike fish as they hit the water surface and below the surface to the point where the projectile loses its forward momentum. Fishes at and just below the surface would be most susceptible to injury or death from strikes, because velocity of these materials would rapidly decrease upon contact with the water and as they travel through the water column. Consequently, most water column fishes would have ample time to detect and avoid approaching munitions or fragments that fall through the water column. Even for an extreme case of expending all small-caliber projectiles within a single gunnery box, the probability of any of these items striking a fish (even as large as bluefin tuna or whale sharks) is extremely low. Therefore, since most fishes are smaller than bluefin tuna or whale sharks, and most military expended materials are less abundant than small-caliber projectiles, the risk of strike by these items is exceedingly low for fish overall. A possibility exists that a small number of fish at or near the surface may be directly impacted if they are in the target area and near the point of physical impact at the time of military expended material strike, but population-level impacts would not occur.

Sinking exercises occur in open ocean areas, outside of the coastal range complexes. While serious injury or mortality to individual fish would be expected if they were present within range of high-explosive activities (analyzed in Section 3.6.3.1, Acoustic Stressors), sinking exercises under Alternative 1 would not result in impacts on pelagic fish populations at the surface based on the placement of these activities in deep ocean areas where fish abundance is low or widely dispersed. Also, these activities are very few in number. Disturbances to benthic fishes from sinking exercises would be highly localized to the sinking exercise box. Any deep-sea fishes on the bottom where a ship hulk would settle could experience displacement, injury, or death. However, population level impacts on the deep-sea fish community would not occur because of the limited spatial extent of the impact and the wide dispersal of fish in deep ocean areas.

All of the ESA-listed fish species occurring in training areas would be potentially exposed to military expended materials. The Atlantic salmon occurs only in the Northeast Range Complexes and in the three northernmost Large Marine Ecosystems, where the density of military expended materials is very low. Therefore, while military expended materials could overlap with Atlantic salmon, the likelihood of a strike would be extremely low, with discountable effects. Within the Study Area, scalloped hammerhead sharks belonging to the Central and Southwestern Atlantic Distinct Population Segment occur only in the North Atlantic Gyre Open Ocean Area, the Caribbean Sea Large Marine Ecosystem and around Puerto Rico, and the southeastern portion of the Gulf of Mexico Large Marine Ecosystem adjacent to the Key West OPAREA. Therefore, while military expended materials could overlap with scalloped hammerhead sharks, the likelihood of a strike would be extremely low, with discountable effects. Nassau groupers are found in reefs areas of the Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems. Even though there's likely some overlap with military expended materials and Nassau grouper, the likelihood of a strike would be extremely low, with discountable effects. All sturgeon are restricted to the continental shelf, particularly the shallow, coastal, or nearshore waters of the Study Area (Dadswell, 2006; Ross et al., 2009) and, therefore, could be exposed to military expended materials in these locations. Sawfishes typically occur in shallow coastal waters of South Florida and the Gulf of Mexico, usually near the ocean bottom, but may occur out to depths of 120 m.

Giant manta rays and oceanic whitetip sharks may occur anywhere within the Study Area as far north as New Jersey. Therefore, the giant manta ray has the potential to be present in most areas where training activities involving the use of military expended materials occur. As giant manta rays and oceanic whitetip sharks are often found near surface waters, it is possible that they may be struck by projectiles and other military expended materials as they enter the water. However, given the scarcity of these species, it is highly unlikely that a giant manta ray or oceanic whitetip shark would be present at a given time or place that an activity is taking place. There is no overlap of military expended materials use with designated critical habitat for Atlantic salmon or smalltooth sawfish. All of the physical and biological features required by Atlantic salmon within the Study Area are applicable to freshwater only and are outside of areas where military materials may be expended. Therefore, none of the military expended materials would affect Atlantic salmon critical habitat. The physical and biological features for smalltooth sawfish critical habitat are red mangrove habitats and shallow marine waters of less than 1 m deep. No activities involving military expended materials would occur at these depths and thus would not overlap with smalltooth sawfish critical habitat. Military expended materials could be expended within Gulf sturgeon critical habitat within coastal waters where the Panama City Operating Area overlaps with the critical habitat. Likewise, the use of military expended materials during training activities overlaps with the designated critical habitat for Atlantic sturgeon in the James and York rivers in Virginia, the Cooper River in South Carolina, and the Savannah River in Georgia. In each case for both Gulf and Atlantic sturgeon critical habitat, while overlap occurs, military expended materials from training exercises are not anticipated to impact any of the physical and biological features identified for these habitats.

The Navy will implement mitigation (e.g., not conducting gunnery activities within a specified distance of shallow-water coral reefs) to avoid potential impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources). The mitigation will consequently help avoid potential impacts on fishes that inhabit shallow-water coral reefs.

The impact of military expended material strikes on fishes would be inconsequential due to: (1) the limited number of species found directly at the surface where military expended material strikes could occur, (2) the rare chance that a fish might be directly struck at the surface by military expended materials, (3) the ability of most fishes to detect and avoid an object falling through the water below the surface, and (4) the implementation of mitigation. The potential impacts of military expended material strikes would be short term (seconds) and localized disturbances of the water surface (and seafloor areas within sinking exercise boxes) and are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction at the population level.

Pursuant to the ESA, military expended material from training activities, as described under Alternative 1, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish critical habitat. Military expended materials from training activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Military Expended Materials under Alternative 1 for Testing Activities

Appendix F (Military Expended Materials and Direct Strike Impact Analyses) has more information on the type and quantities of military expended materials proposed to be used. The type, quantity, and location of testing activities would be substantially less than training activities described above.

Potential impacts from military expended material strikes on marine fish groups and ESA-listed species during testing activities would be similar to those described for comparable training activities. Some fish species potentially impacted by testing activities would be different than those fishes impacted during training activities based on the specific activity and the location of the activity. For example, torpedoes are tested at nine locations (Table 3.0-26 and Table 3.0-28) compared to four training locations (Table 3.0-24 and Table 3.0-27). Military expended materials hitting the water could result in an extremely unlikely strike of an individual fish, or more likely in a short-term and local displacement of fishes in the water column. However, these behavioral reactions are not expected to result in substantial changes to an individual's fitness or species recruitment, and are not expected to result in population-level impacts.

Similarly, military expended materials are not anticipated to overlap with designated critical habitat for Atlantic salmon, smalltooth sawfish, or Atlantic sturgeon. Military expended materials could be expended within Gulf sturgeon critical habitat within coastal waters where the Panama City Operating Area overlaps with the critical habitat. While overlap with Gulf sturgeon critical habitat may occur, military expended materials from testing exercises are not anticipated to impact any of the physical and biological features identified for these habitats.

The Navy will implement mitigation (e.g., not conducting gunnery activities within a specified distance of shallow-water coral reefs) to avoid potential impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources). The mitigation will consequently help avoid potential impacts on fishes that inhabit shallow-water coral reefs.

The impact of military expended material strikes would be inconsequential due to: (1) the limited number of species found directly at the surface where military expended material strikes could occur, (2) the rare chance that a fish might be directly struck at the surface by military expended materials, (3) the ability of most fishes to detect and avoid an object falling through the water below the surface, and (4) the implementation of mitigation. The potential impacts of military expended material strikes would range from short-term (seconds) and localized disturbances of the water surface and long-term impacts for individuals if struck. However, these impacts are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction at the population level.

Pursuant to the ESA, military expended material from testing activities, as described under Alternative 1, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish critical habitat. Military expended materials from training activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.4.3.2 Impacts from Military Expended Materials under Alternative 2

Impacts from Military Expended Materials under Alternative 2 for Training Activities

Even though the number of military expended materials used during training activities under Alternative 2 would be slightly greater relative to Alternative 1 (see Section 3.0.3.3.4.2, Military Expended Materials), the difference is negligible. Physical disturbance and strike stress experienced by fishes from military expended materials under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended material from training activities, as described under Alternative 2, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish critical habitat. Military expended materials from training activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

Impacts from Military Expended Materials under Alternative 2 for Testing Activities

Even though the number of military expended materials used during testing activities under Alternative 2 would be slightly greater relative to Alternative 1 (see Section 3.0.3.3.4.2, Military Expended Materials), the difference is negligible. Physical disturbance and strike stress experienced by fishes from military expended materials under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended material from testing activities, as described under Alternative 2, would have no effect on Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish critical habitat. Military expended materials from training activities under Alternative 1 may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.4.3.3 Impacts from Military Expended Materials under the No Action Alternative

Impacts from Military Expended Materials under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Various military expended materials stressors for fishes would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.4.4 Impacts from Seafloor Devices

The number and location of activities including seafloor devices is presented in Section 3.0.3.3.4.3 (Seafloor Devices). Additional information on stressors by testing and training activity is provided in Appendix B (Activity Stressor Matrices). Seafloor devices 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 underwater vehicles, and bottom-placed targets that are not expended. As discussed in the military expended materials strike section, objects falling through the water column would slow in velocity as they sink toward the bottom and could be avoided by most, if not all fish.

Seafloor devices with a strike potential for fish include those items temporarily deployed on the seafloor. The potential strike impacts of unmanned underwater vehicles (e.g., bottom crawl vehicles) are also included here. Some fishes are attracted to virtually any tethered object in the water column for food or refuge (Dempster & Taquet, 2004) and could be attracted to a non-explosive mine assembly. However, while a fish might be attracted to the object, its sensory abilities allow it to avoid colliding with fixed tethered objects in the water column (Bleckmann & Zelick, 2009), so the likelihood of a fish striking one of these objects is implausible. Therefore, strike hazards associated with collision into other seafloor devices such as deployed mine shapes or anchored devices are highly unlikely to pose any strike hazard to fishes and are not discussed further.

3.6.3.4.4.1 Impacts from Seafloor Devices under Alternative 1

Impacts from Seafloor Devices under Alternative 1 for Training Activities

Table 3.0-35 shows the number and location of activities that use seafloor devices. As indicated in Section 3.0.3.3.4.3 (Seafloor Devices), under Alternative 1, training activities that deploy seafloor devices occur in the Northeast and Southeast U.S. Continental Shelf, Caribbean, and Gulf of Mexico Large Marine Ecosystems and the Gulf Stream Open Ocean Area—specifically within seven locations, including Virginia Capes Range Complex, Navy Cherry Point Range Complex, Jacksonville Range Complex, Key West Range Complex, Gulf of Mexico Range Complex, Naval Surface Warfare Center Panama City Testing Range, and several inshore water locations (see Table 3.0-36).

Aircraft deployed mine shapes, anchor blocks, anchors, and bottom-placed instruments, and targets all have the potential to strike fish upon deployment as they are sinking through the water column and settling on the seafloor. While seafloor device use during training activities could overlap with ESA-listed species, with the exception of Atlantic salmon, the likelihood of a strike would be extremely low given the low abundance of ESA-listed species recorded in the Study Area, the ability for the species to detect and avoid falling objects through the water below the surface, and the dispersed nature of the activities. However, there would be the potential for effect.

Activities that employ seafloor devices would overlap the critical habitat of the Atlantic sturgeon and Gulf sturgeon. For example, the use of seafloor devices during training activities would overlap designated critical habitat for Atlantic sturgeon in inshore waters such as the Delaware River in Delaware, James and York rivers in Virginia and Savannah and St. Marys rivers in Georgia and with Gulf sturgeon critical habitat within coastal waters where the Panama City Operating Area overlaps with the critical habitat. Seafloor device use would not overlap with designated Atlantic salmon and smalltooth sawfish critical habitat.

The Navy will implement mitigation that includes not conducting precision anchoring (except in designated anchorages) within the anchor swing circle of shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks to avoid potential impacts from seafloor devices on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources). This mitigation will consequently help avoid potential impacts on fishes that inhabit these areas.

Pursuant to the ESA, the use of seafloor devices during training activities, as described under Alternative 1, would have no effect on Atlantic salmon and designated critical habitat for Atlantic salmon and smalltooth sawfish. The use of seafloor devices during training activities may affect Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish, and may affect designated critical habitat for Atlantic sturgeon and Gulf sturgeon. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Seafloor Devices under Alternative 1 for Testing Activities

Table 3.0-35 shows the number and location of activities that use seafloor devices. As indicated in Section 3.0.3.3.4.3 (Seafloor Devices), under Alternative 1, testing activities that deploy seafloor devices occur in the Northeast Range Complexes, Virginia Capes Range Complex, Navy Cherry Point Range Complex, Jacksonville Range Complex, Key West Range Complex, Gulf of Mexico Range Complex, Naval Undersea Warfare Center Newport Testing Range, South Florida Ocean Measurement Facility, and Naval Surface Warfare Center Panama City Testing Range.

As discussed in Section 3.6.3.4.3 (Impacts from Military Expended Materials), objects falling through the water column would slow in velocity as they sink toward the bottom and could be avoided by most fishes. While seafloor device use during training activities could overlap with ESA-listed species, the likelihood of a strike would be extremely low given the low abundance of ESA-listed species recorded in the Study Area, the ability for the species to detect and avoid falling objects through the water below the surface, and the dispersed nature of the activities. However, there would be the potential for effect.

Activities that employ seafloor devices would overlap the critical habitat of Gulf sturgeon. For example, the use of seafloor devices during testing activities would overlap with Gulf sturgeon critical habitat within coastal waters in the Panama City Operating Area. Seafloor device use would not overlap with designated Atlantic salmon, Atlantic sturgeon, and smalltooth sawfish critical habitat.

The Navy will implement mitigation to avoid potential impacts from seafloor devices on seafloor resources in mitigation areas within the South Florida Ocean Measurement Facility, as discussed in Section 5.4.1 (Mitigation Areas for Seafloor Resources). For example, the Navy will use real-time geographic information system and global positioning system (along with remote sensing verification) during deployment, installation, and recovery of anchors and mine-like objects to avoid impacts on shallow-water coral reefs and live hard bottom. This mitigation will consequently help avoid potential impacts on fishes that occur in these areas.

Pursuant to the ESA, the use of seafloor devices during testing activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, and smalltooth sawfish. The use of seafloor devices during testing activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish, and may affect designated critical habitat for Gulf sturgeon. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.4.4.2 Impacts from Seafloor Devices under Alternative 2

Impacts from Seafloor Devices under Alternative 2 for Training Activities

Because training activities under Alternative 2 occur at the same rate and frequency relative to Alternative 1, physical disturbance and strike stress experienced by fishes from seafloor device use under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of seafloor devices during training activities, as described under Alternative 2, would have no effect on Atlantic salmon and designated critical habitat for Atlantic salmon and smalltooth sawfish. The use of seafloor devices during training activities may affect Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish, and may affect designated critical habitat for Atlantic sturgeon and Gulf sturgeon.

Impacts from Seafloor Devices under Alternative 2 for Testing Activities

Because testing activities under Alternative 2 occur at a similar rate and frequency relative to Alternative 1, physical disturbance and strike stress experienced by fishes from seafloor device use under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of seafloor devices during testing activities, as described under Alternative 2, would have no effect on Atlantic salmon or designated critical habitat for Atlantic salmon, Atlantic sturgeon, and smalltooth sawfish. The use of seafloor devices during testing activities may affect Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and

Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish, and may affect designated critical habitat for Gulf sturgeon.

3.6.3.4.4.3 Impacts from Seafloor Devices under the No Action Alternative

Impacts from Seafloor Devices under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Stressors for fishes such as seafloor devices would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.4.5 Impacts from Pile Driving

Impact pile driving and vibratory pile removal would occur during training for the construction of an Elevated Causeway System, as described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.3-2. This activity was considered as a potential physical disturbance stressor. Section 3.0.3.3.1.3 (Pile Driving) provides additional details on pile driving and noise levels measured from similar construction activity. Pile driving during construction of an Elevated Causeway System would not occur during testing activities in the AFTT Study Area.

While impacts to fishes from pile driving activities as an acoustic stressor are addressed Section 3.6.3.1.4 (Impacts from Pile Driving), this section addresses the physical presence of the resulting temporary pier as part of the Elevated Causeway System as a potential physical disturbance stressor. The size of the pier would be no greater than 1,520 feet long, consisting of 119 supporting piles, on the beach and out into shallow coastal waters of Joint Expeditionary Base Little Creek-Fort Story in the Virginia Capes Range Complex or Marine Corps Base Camp Lejeune in the Navy Cherry Point Range Complex. Given the nearshore locations for this training activity and the temporary nature of the structures, it is not likely that fishes would experience physical disturbance from the presence of the temporary pier structure. Furthermore, it is not likely that a fish would be struck by a piling during installation because they are mobile and would be able to avoid the physical disturbance and strike stressors. Although some ESA-listed species such as Atlantic sturgeon, shortnose sturgeon, and giant manta rays may be present in the vicinity of pile driving activities, it is also unlikely that they would be struck by a pile. In addition, there is also no overlap between pile driving activities and the designated critical habitats for any ESA-listed species. Therefore, the Navy has determined that the Elevated Causeway System training activity would not result in physical disturbance or strike impacts above those acoustic impacts described in Section 3.6.3.1.4 (Impacts from Pile Driving) and are not considered further in this section.

Physical disturbance and strike stressors from pile driving are not applicable to fishes because pile driving does not occur during testing activities. Pursuant to the ESA, the use of driving during training activities would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. Pile driving during training activities would have no effect on Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.5 Entanglement Stressors

This section evaluates potential entanglement impacts of various types of expended materials used by the Navy during training and testing activities within the Study Area. The likelihood of fishes being affected by an entanglement stressor is a function of the physical properties, location, and buoyancy of the object and the behavior and physical features of the fish, as described in Section 3.0.3.6.4 (Conceptual Framework for Assessing Effects from Entanglement). Three types of military expended materials are considered here: (1) wires and cables (2) decelerators/parachutes, and (3) biodegradable polymer.

Most entanglement observations involve abandoned or discarded nets, lines, and other materials that form loops or incorporate rings (Derraik, 2002; Keller et al., 2010; Laist, 1987; Macfadyen et al., 2009). A 25-year dataset assembled by the Ocean Conservancy reported that fishing line, rope, and fishing nets accounted for 68 percent of fish entanglements, with the remainder due to encounters with various items such as bottles, cans, and plastic bags (Ocean Conservancy, 2010). No occurrences involving military expended materials were documented.

Fish entanglement occurs most frequently at or just below the surface or in the water column where objects are suspended. A smaller number involve objects on the seafloor, particularly abandoned fishing gear designed to catch bottom fishes or invertebrates (Ocean Conservancy, 2010). More fish species are entangled in coastal waters and the continental shelf than elsewhere in the marine environment because of higher concentrations of human activity (e.g., fishing, sources of entangling debris), higher fish abundances, and greater species diversity (Helfman et al., 2009; Macfadyen et al., 2009). The consequences of entanglement range from temporary and inconsequential to major physiological stress or mortality.

Some fishes are more susceptible to entanglement in derelict fishing gear and other marine debris, compared to other fish groups. Physical features, such as rigid or protruding snouts of sawfishes and sturgeon and some elasmobranchs (e.g., the wide heads of hammerhead sharks and cephalic fins on manta rays), increase the risk of entanglement compared to fishes with smoother, more streamlined bodies (e.g., lampreys and eels). High rates of shark mortality have been associated with entanglement in fish aggregating devices (Filmalter et al., 2013). Sawfishes occur only in nearshore, and continental shelf waters of the Gulf of Mexico Large Marine Ecosystem and portions of the Southeast U.S. Continental Shelf Large Marine Ecosystem (74 *Federal Register* 45353 and 74 *Federal Register* 37671), where they are concentrated in south Florida and the Florida Keys. Scalloped hammerhead sharks, giant manta rays, oceanic whitetip sharks, and ESA-listed sturgeon species occur in nearshore and offshore waters within one or more of the Large Marine Ecosystems that overlap Navy training and testing areas in the Study Area. Most fishes, except for jawless fishes and eels that are too smooth and slippery to become entangled, are susceptible to entanglement in gear specifically designed for that purpose (e.g., gillnets). The Navy uses a biodegradable polymer to function as entanglement objects. Biodegradable polymer systems designed to entangle the propellers of small in-water vessels would only be used during testing activities, not during training and the number and location of proposed testing activities is presented in Table 3.0-42.

The overall impacts of entanglement are highly variable, ranging from temporary disorientation to mortality due to predation or physical injury. The evaluation of a species' entanglement potential should consider the size, location, and buoyancy of an object as well as the size, physical characteristics, and behavior of the fish species.

The following sections seek to identify entanglement potential due to military expended material. Where appropriate, specific geographic areas (Large Marine Ecosystems, open ocean areas, range complexes, testing ranges, and bays and inshore waters) of potential impact are identified.

3.6.3.5.1 Impacts from Wires and Cables

Fiber optic cables, guidance wires, and sonobuoys (which contain a wire) are used during training and testing activities. The number and location of items expended under each alternative is presented in Sections 3.0.3.3.5.1 (Wires and Cables), with additional details on types of activities that include this stressor provided in Appendix B (Activity Stressor Matrices, Tables B-1 and B-2).

Some fiber optic cables used during Navy training and testing associated with remotely operated mine neutralization activities would be expended, although a portion may be recovered. The length of the expended tactical fiber would vary (up to about 3,000 m) depending on the activity. Tactical fiber has an 8-micrometer (0.008 mm) silica core and acylate coating, and looks and feels like thin monofilament fishing line. Other characteristics of tactical fiber are a 242-micrometer (0.24 mm) diameter, 12 lb. tensile strength, and 3.4-mm bend radius (Corning Incorporated, 2005; Ratheon, 2015). Tactical fiber is relatively brittle; it readily breaks if knotted, kinked, or abraded against a sharp object. Deployed tactical fibers breaks if looped beyond its bend radius (3.4 mm), or exceeds its tensile strength (12 lb.). If the fiber becomes looped around an underwater object or marine animal, it does not tighten unless it is under tension. Such an event would be unlikely based on its method of deployment and its resistance to looping after it is expended. The tactical fibers are often designed with controlled buoyancy to minimize the fiber's effect on vehicle movement. The tactical fiber would be suspended within the water column during the activity, and then be expended and sink to the seafloor (effective sink rate of 1.45 cm/second [Raytheon, 2015]) where it would be susceptible to abrasion and burial by sedimentation. Additionally, encounter rates with fiber optic cables is limited by the small number that are expended.

Major fish groups identified in Table 3.6-2 that could be susceptible to entanglement in expended cables and wires are those like sawfishes, with elongated snouts lined with tooth-like structures that easily snag on other similar marine debris, such as derelict fishing gear (Macfadyen et al., 2009). Some elasmobranchs (hammerhead sharks and manta rays) and billfishes occurring within the offshore and continental shelf portions of the range complexes and testing ranges (where the potential for entanglement would occur) could be susceptible to entanglement in cables and wires. Species occurring outside the specified areas within these range complexes and testing ranges would not be exposed to fiber optic cables or guidance wires and sonobuoy wires.

Once a guidance wire is released, it is likely to sink immediately and remain on the seafloor. In some cases, the wire may snag on a hard structure near the bottom and remain partially or completely suspended. The types of fish that encounter any given wire would depend, in part, on its geographic location and vertical location in the water column. In any situation, the most likely mechanism for entanglement would involve fish swimming through loops in the wire that tighten around it; however, loops are unlikely to form in a guidance wire or sonobuoy wire because of its size and rigidity (Environmental Sciences Group, 2005).

Because of their physical characteristics, guidance wires and fiber optic cables pose a potential, though unlikely, entanglement risk to susceptible fishes. Analysis of potential entanglement for fishes is based on abandoned monofilament, nylon, and polypropylene lines used in commercial nets. Such derelict fishing gear is abundant in the ocean (Macfadyen et al., 2009) and pose a greater hazard to fishes than the wires expended by the Navy. Fishing gear materials often have breaking strengths that can be up to orders of magnitude greater than that of guidance wire and fiber optic cables (Environmental Sciences Group, 2005), and are far more prone to tangling, as discussed in Section 3.0.3.3.5.1 (Wires and Cables). Fiber optic cables do not easily form loops, are brittle, and break easily if bent, so they pose a negligible entanglement risk. Additionally, the encounter rate and probability of impact from guidance wires and fiber optic cables are low, as few are expended.

Tube-launched optically tracked wire-guided missiles would expend wires in the nearshore or offshore waters of the Navy Cherry Point Range Complex during training only, and are discussed together with torpedo guidance wires because their potential impacts would be similar to those described here for torpedo guidance wires.

Sonobuoys consist of a surface antenna and float unit and a subsurface hydrophone assembly unit. The two units are attached through a thin gauge, dual-conductor, and hard-draw copper strand wire, which is then wrapped by a hollow rubber tubing or bungee in a spiral configuration. The tensile breaking strength of the wire is a maximum of 40.4 lb. (Swope & McDonald, 2013). The length of the cable is housed in a plastic canister dispenser, which remains attached upon deployment. The length of wire that extends out is no more than 1,500 ft. and is dependent on the water depth and type of sonobuoy. Attached to the wire is a kite-drogue and damper disk stabilizing system made of non-woven nylon fabric. The nylon fabric is very thin and can be broken by hand. The wire runs through the stabilizing system, and leads to the hydrophone components. The hydrophone components may be covered by thin plastic netting depending on type of sonobuoy, but pose no entanglement risk. Each sonobuoy has a saltwater-activated polyurethane float that inflates when the sonobuoy is submerged and keeps the sonobuoy components floating vertically in the water column below it. Sonobuoys remain suspended in the water column for no more than 30 hours, after which they sink to the seafloor.

The sonobuoy itself is not considered an entanglement hazard upon deployment (Environmental Sciences Group, 2005), but their components may pose an entanglement hazard once released into the ocean. Aerial-launched sonobuoys are deployed with a decelerator/parachute. Sonobuoys contain cords, electronic components, and plastic mesh that may entangle fish (Environmental Sciences Group, 2005). Open-ocean filter feeding species, such as basking sharks, whale sharks, and manta rays could become entangled in these items, whereas smaller species such as Atlantic herring could become entangled in the plastic mesh in the same manner as a small gillnet. Smalltooth sawfish, scalloped hammerheads, Nassau grouper, giant manta rays, oceanic whitetip sharks, and sturgeon may co-occur with newly expended sonobuoy, as these fishes are found in areas where sonobuoys are expended. Additionally, since most sonobuoys are expended in offshore areas, many other coastal fishes would not encounter or have any opportunity to become entangled in materials associated with sonobuoys, apart from the risk of entanglement in decelerators/parachutes mentioned above.

3.6.3.5.1.1 Impacts from Wires and Cables under Alternative 1

Impacts from Wires and Cables under Alternative 1 for Training Activities

Fiber optic cables may be expended within the Virginia Capes, Navy Cherry Point, Jacksonville, and Gulf of Mexico range complexes. Given the locations of training activities, Atlantic salmon, Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, smalltooth sawfish, oceanic whitetip sharks, and giant manta rays may be exposed to expended cables and wires. Atlantic salmon occur only in the Northeast Range Complexes where the density of expended wires and cables is very low. Atlantic and shortnose sturgeon could encounter fiber optic cables in the Virginia Capes, Navy Cherry Point, or Jacksonville Range Complexes; smalltooth sawfish could occur in the Jacksonville Range Complex as well. Nassau grouper occur in the Jacksonville and Gulf of Mexico range complexes. For sawfishes, early life stages have the same body-type as adults. However, the likelihood of entanglement of early life stages would be less than that of adults, because nursery habitats are found in very shallow water (less than 1 m deep)

(National Marine Fisheries Service, 2009e), where no cables or wires would be expended. Early life stages of sturgeon and Atlantic salmon are typically (or exclusively, for salmon) found in freshwater rivers and not in marine environments, so only sub-adults and adults would be potentially exposed to entanglement stressors. Gulf sturgeon could encounter fiber-optic cables because they are expended during training activities where these species are found, including the Gulf of Mexico. Giant manta rays and oceanic whitetip sharks occur in offshore areas in the large marine ecosystems where training activities would occur. While entanglement is possible, these species would be able to break the wires and cables.

Guidance wires may be expended in the Northeast, Virginia Capes, and Jacksonville range complexes, as well as in the designated Sinking Exercise areas. Benthic-associated ESA-listed species, including Atlantic and shortnose sturgeon, and smalltooth sawfish, could encounter guidance wire because they can occur in nearshore waters out to the shelf break, where they feed on the bottom and could become entangled in a guidance wire while feeding. Pelagic species such as Atlantic salmon and oceanic whitetip sharks may encounter guidance wires in the water column. Guidance wires sink too quickly to be transported very far before reaching the seafloor (Environmental Sciences Group, 2005), thus limiting the amount of exposure time for pelagic species. Gulf sturgeon would not be exposed to guidance wires as they would not be expended within the waters of the northern Gulf of Mexico where this species occurs. Fish would rarely encounter guidance wires expended during training activities. If a guidance wire were encountered, the most likely result would be that the fish ignores it, which is an inconsequential and immeasurable effect. In the rare instance where an individual fish became entangled in guidance wire and could not break free, the individual could be impacted as a result of impaired feeding, bodily injury, or increased susceptibility to predators. However, this is an extremely unlikely scenario because the density of guidance wires would be very low, as discussed in Section 3.0.3.3.5.1 (Wires and Cables).

Sonobuoy wires may be expended within any of the range complexes throughout the Study Area. As described above, a sonobuoy wire runs through the stabilizing system and leads to the hydrophone components. The hydrophone components may be covered by thin plastic netting depending on type of sonobuoy, but pose no entanglement risk. This is mainly due to the sonobuoy being made of a single wire that hangs vertically in the water column. Therefore, it would be highly unlikely that a fish, including ESA-listed species would be entangled by a sonobuoy wire.

While individual fish susceptible to entanglement could encounter guidance wires, fiber optic cables, and sonobuoy wires, the long-term consequences of entanglement are unlikely for either individuals or populations because (1) the encounter rate for cables and wires is low, (2) the types of fishes that are susceptible to these items is limited, (3) the restricted overlap with susceptible fishes, and (4) the physical characteristics of the cables and wires reduce entanglement risk to fishes compared to monofilament used for fishing gear. Potential impacts of exposure to guidance wires and fiber optic cables are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

Pursuant to the ESA, the use of wires and cables during training activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish and no effect on Nassau grouper and the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks. The use of wires and cables during training activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Wires and Cables under Alternative 1 for Testing Activities

As discussed in Section 3.0.3.3.5.1 (Wires and Cables), under Alternative 1 testing activities, fiber optic cables, guidance wires, and sonobuoy components that would pose an entanglement risk to marine fishes, including ESA-listed species, would be similar to those described training activities, even though testing activities occur at a higher frequency and in more locations compared to training activities. Testing activities involving wires and cables occur at Virginia Capes Range Complex, Jacksonville Range Complex, Key West Range Complex, Northeast Range Complexes, Navy Cherry Point Range Complex, Gulf of Mexico Range Complex, Naval Undersea Warfare Center Newport Testing Range, Naval Surface Warfare Center Panama City Testing Range, and South Florida Ocean Measurement Facility.

Atlantic salmon would not be as prone to entanglement because they do not possess the morphological features (rigid or protruding snouts) associated with high entanglement rates. ESA-listed species more susceptible to entanglement (sawfish and sturgeon species, scalloped hammerhead sharks, and giant manta rays) and those not as susceptible to entanglement (Atlantic salmon, Nassau grouper, and oceanic whitetip sharks) occur in testing locations, but are unlikely to encounter the guidance wires because of their low densities in the areas where they are expended. Early life stages of sturgeon and Atlantic salmon are typically (or exclusively, for salmon) found in freshwater rivers and not in marine environments, so only sub-adults and adults would be potentially exposed to entanglement stressors. For sawfishes, the early life stages have the same body-type as adults; however, the likelihood of entanglement of early life stages would be slightly less than that of adults, because nursery habitats are found in very shallow water (less than 1 m deep), where no cables or wires would be expended. The Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks may encounter expended cables and wires in the Key West Range Complex, while the Nassau grouper may encounter expended cables and wires in the Key West Range Complex and the South Florida Ocean Measurement Facility.

While individual fish susceptible to entanglement could encounter guidance wires, fiber optic cables, and sonobuoy wires, the long-term consequences of entanglement are unlikely for either individuals or populations because (1) the encounter rate for cables and wires is low, (2) the types of fishes that are susceptible to these items is limited, (3) the restricted overlap with susceptible fishes, and (4) the physical characteristics of the cables and wires reduce entanglement risk to fishes compared to monofilament used for fishing gear. Potential impacts from exposure to guidance wires and fiber optic cables are not expected to result in substantial changes to an individual’s behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

Pursuant to the ESA, the use of wires and cables during testing activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. The use of wires and cables during testing activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.5.1.2 Impacts from Wires and Cables under Alternative 2

Impacts from Wires and Cables under Alternative 2 for Training Activities

Because activities under Alternative 2 occur at a similar rate and frequency relative to Alternative 1, entanglement stress experienced by fishes from guidance wires, fiber optic cables, and sonobuoy wires under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of wires and cables during training activities, as described under Alternative 12, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish and no effect on Nassau grouper and the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks. The use of wires and cables during training activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish.

Impacts from Wires and Cables under Alternative 2 for Testing Activities

Even though testing activities under Alternative 2 occur at a slightly higher rate and frequency relative to Alternative 1, entanglement stress experienced by fishes from guidance wires, fiber optic cables, and sonobuoy wires under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, the use of wires and cables during testing activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish. The use of wires and cables during testing activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.5.1.3 Impacts from Wires and Cables under the No Action Alternative

Impacts from Wires and Cables under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Entanglement stressors for fishes from wires and cables would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.5.2 Impacts from Decelerators/Parachutes

Decelerators/Parachutes of varying sizes are used during training and testing activities. Section 3.0.3.3.5.2 (Decelerators/Parachutes) describes the use and platforms where decelerators/parachutes would be released into the marine environment and therefore present an entanglement risk to fishes. The types of activities that use decelerators/parachutes can be found in Appendix B (Activity Stressor Matrices), the physical characteristics and size of decelerators/parachutes, locations where decelerators/parachutes are used, and the number of decelerator/parachutes that are proposed to be used under each alternative are presented in Section 3.0.3.3.5.2 (Decelerators/Parachutes).

Once a decelerator/parachute has been released to the water, it poses a potential entanglement risk to fishes. The Naval Ocean Systems Center identified the potential impacts of torpedo air launch accessories, including decelerators/parachutes, on fish (U.S. Department of the Navy, 2001a). Unlike other materials in which fish become entangled (such as gill nets and nylon fishing line), the decelerator/parachute is relatively large and visible, reducing the chance that visually oriented fish would accidentally become entangled in it. No cases of fish entanglement have been reported for decelerators/parachutes (Ocean Conservancy, 2010; U.S. Department of the Navy, 2001a). Entanglement in a newly expended decelerator/parachute and its attachment lines while it is in the water column is unlikely because fish generally react to sound and motion at the surface with a behavioral reaction by swimming away from the source (see Section 3.6.3.4.3, Impacts from Military Expended Materials) and would detect the oncoming decelerator/parachute in time to avoid contact. While the decelerator/parachute is sinking, fish would have ample opportunity to swim away from the large moving object. Even if the decelerator/parachute landed directly on a fish, it would likely be able to swim away faster than the decelerator/parachute would sink because the resistance of the water would slow the decelerator/parachute's downward motion.

Once the decelerator/parachute is on the bottom, however, it is feasible that a fish could become entangled in the decelerator/parachute or its attachment lines while diving and feeding, especially in deeper waters where it is dark. If the decelerator/parachute dropped in an area of strong bottom currents, it could billow open and pose a short-term entanglement threat to large fish feeding on the bottom. Benthic fishes with elongated spines could become caught on the decelerator/parachute or lines. Most sharks and other smooth-bodied fishes are not expected to become entangled because their soft, streamlined bodies can more easily slip through potential snares. A fish with spines or protrusions (e.g., some sharks, manta rays, billfishes, sturgeon, or sawfishes) on its body that swam into the decelerator/parachute or a loop in the lines, and then struggled, could become bound tightly enough to prevent escape. Although this scenario is possible based on the structure of the materials and the shape and behavior of fishes, it is not considered a likely event.

3.6.3.5.2.1 Impacts from Decelerators/Parachutes under Alternative 1

<u>Impacts from Decelerators/Parachutes under Alternative 1 for Training Activities</u>

Fish species that could be susceptible to entanglement in decelerators/parachutes are the same as discussed for cables and wires. As discussed in Section 3.0.3.3.5.2 (Decelerators/Parachutes), there are four sizes of parachutes used during training activities. Air-launched sonobuoys deploy a small parachute (18 in. in diameter) to slow their descent to the water and would be deployed primarily in the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, and Key West Range Complexes, but may be used anywhere in the Study Area. Air-dropped lightweight torpedoes utilize a small-sized parachute, approximately 48 in. in diameter, for the same purpose. These items would only be deployed in the Virginia Capes and Jacksonville Range Complexes in very small numbers (an annual total of 36). Medium parachutes, approximately 19 ft. in diameter, associated with illumination flares, would be deployed in relatively small numbers (an annual total of 144 throughout the entire Study Area) in the Virginia Capes, Navy Cherry Point, Jacksonville, and Key West Range Complexes. Large (30 to 50 ft. in diameter) and extra-large (82 ft. in diameter) parachutes are both associated with aerial targets (drones). A small number of large parachutes (33 total annually) would be used primarily in the Virginia Capes Range Complex, but may also be used in the Northeast, Jacksonville and Gulf of Mexico Range Complexes. Only five extra-large parachutes would be expended annually, solely in the Virginia Capes Range Complex. Based on the numbers and geographic locations of their use, decelerators/parachutes pose a risk of entanglement for all fish species that occur in the Study Area. Table 3.0-32 shows the number and location of decelerator/parachutes expended during proposed training activities under Alternative 1.

Some elasmobranchs (sawfishes, hammerhead sharks, and manta rays), sturgeon, swordfishes, and billfishes occurring within the offshore and continental shelf portions of the range complexes (where the potential for entanglement would occur) may be more susceptible to entanglement in decelerators/parachutes than most fish species due to their unusual body shape or projections. As described above, the highly maneuverable swimming capabilities of these fishes make it unlikely that any entanglement would occur while the decelerators/parachutes are at the surface or sinking through the water column. It is conceivable that ESA-listed species near the seafloor such as a sawfish or sturgeon could encounter an expended decelerator/parachute that has settled to the bottom. These species could encounter decelerators/parachutes because they can occur at the surface or on the bottom in nearshore waters out to the shelf break.

The Atlantic salmon occurs in offshore areas where decelerators/parachutes would be expended in the Northeast Range Complexes and may encounter decelerators/parachutes in the water column. However, the Atlantic salmon, like all salmonids, is a strong swimmer with a streamlined body that is unlikely to become entangled in decelerators/parachutes or lines. The impacts of entanglement with decelerators/parachutes are discountable because of the low density of decelerators/parachutes expended in this location and the body shape of Atlantic salmon, which makes it unlikely to become entangled.

Sawfishes are highly mobile, visual predators that could easily avoid a floating or suspended decelerator/parachute. If a rare decelerator/parachute encounter by a sawfish led to entanglement, the fish would likely thrash its rostral saw in an effort to break free. If such an effort were unsuccessful, the individual could remain entangled, possibly resulting in injury or death. However, this scenario is considered so unlikely that it would be discountable.

For sawfishes, the early life stages have the same body-type as adults; however, the likelihood of entanglement of early life stages would be slightly less than that of adults because nursery habitats are found in very shallow water (less than 1 m deep) (National Marine Fisheries Service, 2009a), where no decelerators/parachutes would be expended. Early life stages of sturgeon and Atlantic salmon are typically (or exclusively, for salmon) found in freshwater rivers and not in marine environments, so only sub-adults and adults would be potentially exposed to entanglement stressors.

Scalloped hammerhead sharks belonging to the Central and Southwest Atlantic Distinct Population Segment may potentially encounter decelerators/parachutes in the Key West Range Complex. Likewise, due to their widespread distribution, giant manta rays may encounter parachutes/decelerators throughout most of the Study Area where these items are used. Both scalloped hammerhead sharks and giant manta rays are highly mobile species that could likely avoid floating or suspended decelerators/parachutes. If a rare decelerator/parachute encounter by one of these species led to entanglement, it would likely thrash in an effort to break free. If such an effort were unsuccessful, the individual could remain entangled, possibly resulting in injury or death. However, this scenario is considered so unlikely that it would be discountable. Similarly, oceanic whitetip sharks occurring offshore could come into contact with a parachute/decelerator during training activities. This species is also a highly mobile, visual predator that could easily avoid floating or suspended decelerators/parachutes or break free if it got entangled.

Nassau groupers are found in reefs areas of the Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea. However, this species is known to have large spawning aggregations in areas such as the ends of islands or reef pinnacles seaward from the general reef contour. This species is highly mobile and could easily avoid floating or suspended decelerators/parachutes, so the likelihood of this species being entangled would be extremely low. If a rare decelerator/parachute encounter by a Nassau grouper led to entanglement, the fish would likely thrash in an effort to break free. If such an effort were unsuccessful, the individual could remain entangled, possibly resulting in injury or death. However, this scenario is considered so unlikely that it would be discountable.

Fishes are unlikely to encounter or become entangled in decelerators/parachutes because of the large size of the range complexes and the resulting widely scattered expended decelerators/parachutes. Individual fish are not prone to be repeatedly exposed to decelerators/parachutes; thus the long-term consequences of entanglement risks from decelerators/parachutes are unlikely for either individuals or populations.

Pursuant to the ESA, the use of decelerators/parachutes during training activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of decelerators/parachutes during training activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Decelerators/Parachutes under Alternative 1 for Testing Activities

As discussed in Section 3.0.3.3.5.2 (Decelerators/Parachutes), under Alternative 1 testing activities, there are four sizes of decelerators/parachutes used. Only small–, medium-, and large-sized parachutes would be expended during testing activities. Small-sized decelerators/parachutes used in conjunction with sonobuoys and light-weight torpedoes and medium-sized decelerators/parachutes, associated with illumination flares, would be used in the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes. In addition, small decelerators/parachutes would also be deployed in the Naval Undersea Warfare Center Newport Testing Range, South Florida Ocean Measurement Facility, and Naval Surface Warfare Center Panama City Testing Range (see Table 3.0-34). Large decelerators/parachutes associated with aerial targets (drones) would primarily be used in the Virginia Capes Range Complex but may also be used in the Northeast, Jacksonville, and Gulf of Mexico Range Complexes. Based on the numbers and geographic locations of their use, decelerators/parachutes pose a risk of entanglement for all ESA-listed fish species that occurs in the Study Area. Table 3.0-34 shows the number and location of each type of decelerators/parachutes expended during proposed testing activities under Alternative 1. Appendix F (Military Expended Materials and Direct Strike Impact Analyses) provides locations, quantities, and impact footprints of expended decelerator/parachutes. Table F-14 and F-15 provides the number of each type of military expended material used for testing activities under Alternative 1.

Based on the numbers and geographic locations of their use, decelerators/parachutes pose a risk of entanglement for all fish species that occurs in the Study Area, including ESA-listed species and would be the same as discussed for cables and wires. It is conceivable that a sawfish or sturgeon could encounter an expended decelerator/parachute that has settled to the bottom. Any of the sturgeon species could encounter decelerators/parachutes because sturgeon can occur at the surface or on the bottom in nearshore waters out to the shelf break. For sawfishes, the early life stages have the same body-type as adults; however, the likelihood of entanglement of early life stages would be slightly less than that of adults because nursery habitats are found in very shallow water (less than 1 m deep), where no decelerators/parachutes would be expended. Early life stages of sturgeon and Atlantic salmon are typically (or exclusively, for salmon) found in freshwater rivers and not in marine environments, so only sub-adults and adults would be potentially exposed to entanglement stressors.

Scalloped hammerhead sharks, oceanic whitetip sharks, and manta rays are highly mobile pelagic species and would likely avoid floating or suspended decelerators/parachutes. If one of these species were to become entangled in a decelerator/parachute, they would likely thrash in an effort to break free. If such an effort were unsuccessful, the individual could remain entangled, possibly resulting in injury or death. This scenario is considered so unlikely that it would be discountable.

Fish are unlikely to encounter or become entangled in decelerators/parachutes because of the large size of the range complexes and testing ranges and the resulting widely scattered expended decelerators/parachutes. Individual fish are not prone to be repeatedly exposed to these entanglement stressors, thus the long-term consequences of entanglement risks from decelerators/parachutes are unlikely for either individuals or populations.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of decelerators/parachutes during testing activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.5.2.2 Impacts from Decelerators/Parachutes under Alternative 2

Impacts from Decelerators/Parachutes under Alternative 2 for Training Activities

Under Alternative 2, the number of decelerators/parachutes that would be expended during training activities would be similar to Alternative 1 and entanglement stress experienced by fishes from decelerators/parachutes under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, the impact conclusion for decelerators/parachutes under Alternative 2 training activities is the same as for Alternative 1.

Pursuant to the ESA, the use of decelerators/parachutes during training activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of decelerators/parachutes during training activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

Impacts from Decelerators/Parachutes under Alternative 2 for Testing Activities

Under Alternative 2, the number of decelerators/parachutes that would be expended during testing activities would be similar to Alternative 1 and entanglement stress experienced by fishes from decelerators/parachutes under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, the impact conclusion for decelerators/parachutes under Alternative 2 testing activities is the same as for Alternative 1.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of decelerators/parachutes during testing activities may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.5.2.3 Impacts from Decelerators/Parachutes under the No Action Alternative

Impacts from Decelerators/Parachutes under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Entanglement stressors for fishes from decelerators/parachutes would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.5.3 Impacts from Biodegradable Polymer

For a discussion of the types of activities that use biodegradable polymers see Appendix B (Activity Stressor Matrices) and for a discussion on where they are used and how many activities would occur under each alternative, see Section 3.0.3.3.5.3 (Biodegradable Polymer). Navy activities that involve vessel entanglement systems include the development of the biodegradable polymer and would only be associated with testing activities in the AFTT Study Area. As indicated by its name, vessel entanglement systems that make use of biodegradable polymers are designed to entangle the propellers of vessels, which would significantly slow and potentially stop the advance of the vessel. A biodegradable polymer is a high molecular weight polymer that degrades to smaller compounds as a result of microorganisms and enzymes. The rate of biodegradation could vary from hours to years and the type of small molecules formed during degradation can range from complex to simple products, depending on whether the polymers are natural or synthetic (Karlsson & Albertsson, 1998). Based on the constituents of the biodegradable polymer the Navy proposes to use, it is anticipated that the material would breakdown into small pieces within a few days to weeks. This would breakdown further and dissolve into the water column within weeks to a few months. The final products, which are all environmentally benign, would be dispersed quickly to undetectable concentrations. Unlike other entanglement stressors, biodegradable polymers only retain their strength for a relatively short period of time; therefore, the potential for entanglement by a fish would be limited. Furthermore, the longer the biodegradable polymer remains in the water, the weaker it becomes making it more brittle and likely to break. A fish would have to encounter the biodegradable polymer after it was expended for it to be a potential entanglement risk. If an animal were to approach the polymer more than a few weeks after it was expended, it is very likely that it would break easily and would not be able to entangle a fish. Since biodegradable polymers are only proposed for testing activities within the AFTT Study Area, the concentration of these items being expended throughout the AFTT Study Area is considered very low and the rate of encounter and risk of entanglement for fishes would be considered extremely low.

3.6.3.5.3.1 Impacts from Biodegradable Polymer under Alternative 1

Impacts from Biodegradable Polymer under Alternative 1 for Training Activities

Biodegradable polymers would not be used during Navy training activities associated with the Proposed Action and therefore will not be analyzed in this section.

Impacts from Biodegradable Polymer under Alternative 1 for Testing Activities

Testing activities under Alternative 1 that use of biodegradable polymers would be conducted within the Virginia Capes, Jacksonville, Key West and Gulf of Mexico Range Complexes, as well as the Naval Undersea Warfare Center Newport Testing Range. Biodegradable polymers would be expended equally throughout these areas.

ESA-listed species such as smalltooth sawfish, Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, oceanic whitetip sharks, and giant manta rays may occur in these range complexes and may be exposed to the biodegradable polymer during testing activities. However, the likelihood of a fish encountering the biodegradable polymers when they are first expended is low because: (1) very few polymers are used annually within each range complex; and (2) polymers only remain intact for relatively short periods of time (generally a few days to weeks) and they are brittle and would break apart over time.

Pursuant to the ESA, the use of biodegradable polymers during testing activities, as described under Alternative 1, would have no effect on Atlantic salmon and would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of biodegradable polymers during testing activities under Alternative 1 may affect Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.5.3.2 Impacts from Biodegradable Polymer under Alternative 2

<u>**Impacts from Biodegradable Polymer under Alternative 2 for Training Activities**</u>

Biodegradable polymers would not be used during Navy training activities associated with the Proposed Action and therefore will not be analyzed in this section.

<u>**Impacts from Biodegradable Polymer under Alternative 2 for Testing Activities**</u>

Testing activities that expend biodegradable polymers under Alternative 2 would be identical to what is proposed under Alternative 1. The analysis presented above in Section 3.6.3.5.3.1 (Impacts from Biodegradable Polymer under Alternative 1) for testing activities would also apply to Alternative 2.

Pursuant to the ESA, the use of biodegradable polymers during testing activities, as described under Alternative 2, would have no effect on Atlantic salmon and would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish. The use of biodegradable polymers during testing activities under Alternative 2 may affect Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, the Central and Southwest Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.5.3.3 Impacts from Biodegradable Polymer under the No Action Alternative

<u>**Impacts from Biodegradable Polymer under the No Action Alternative for Training and Testing Activities**</u>

Biodegradable polymer is not a part of ongoing Navy activities in the Study Area and this entanglement stressor would not be introduced into the marine environment under the No Action Alternative. Therefore, no change in baseline conditions of the existing environment would occur.

3.6.3.6 Ingestion Stressors

This section analyzes the potential ingestion impacts of the various types of munitions and military expended materials other than munitions used by the Navy during training and testing activities within the Study Area. Aspects of ingestion stressors that are applicable to marine organisms in general are presented in Section 3.0.3.6.5 (Conceptual Framework for Assessing Effects from Ingestion). Ingestion of expended materials by fishes could occur in all Large Marine Ecosystems and open ocean areas, and can occur at or just below 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 fish. Floating material is more likely to be eaten by fishes that feed at or near the water surface (e.g., ocean sunfish, basking sharks, whale sharks, manta rays, herring, or flying fishes), while materials that sink to the seafloor present a higher risk to bottom-feeding fishes (e.g., sturgeon, hammerhead sharks, skates, and flatfishes).

It is reasonable to assume that any item of a size that can be swallowed by a fish could be eaten at some time; this analysis focuses on ingestion of materials in two locations: (1) at the surface or water column and (2) at the seafloor. Open-ocean predators and open-ocean planktivores are most likely to ingest materials in the water column. Coastal bottom-dwelling predators and estuarine bottom-dwelling predators could ingest materials from the seafloor. The potential for fish, including the ESA-listed fish species, to encounter and ingest expended materials is evaluated with respect to their feeding group, size, and geographic range, which influence the probability that they would eat military expended materials.

The Navy expends the following types of materials during training and testing in the Study Area that could become ingestion stressors: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, fragments from targets, chaff, flare casings (including plastic end caps and compression pads or pistons), small decelerators/parachutes, and biodegradable polymer. The location and number of expended items that are ingestion stressors are detailed in Section 3.0.3.3.6 (Ingestion Stressors) and the types of activities that include ingestion stressors can be found in in Appendix B (Activity Stressor Matrices). Metal items eaten by fish are generally small (such as fishhooks, bottle caps, and metal springs), suggesting that small- and medium-caliber projectiles are more likely to be ingested. Both physical and toxicological impacts could occur as a result of consuming metal or plastic materials (Dantas et al., 2012; Davison & Asch, 2011; Possatto et al., 2011). Ingestion of plastics has been shown to increase hazardous chemicals in fish leading to liver toxicity of fishes (Rochman et al., 2013). Items of concern are those of ingestible size that either drift at or just below the surface (or in the water column) for a time or sink immediately to the seafloor. The likelihood that expended items would cause a potential impact on a given fish species depends on the size and feeding habits of the fish and the rate at which the fish encounters the item and the composition of the item. In this analysis only small- and medium-caliber munitions (or small fragments from larger munitions), chaff, small decelerators/parachutes, and end caps and compression pads or pistons from flares and chaff cartridges are considered to be of ingestible size for a fish. For many small fish species (e.g., herring, anchovy, etc.), even these items (with the exception of chaff) are often too large to be ingested, even though small pieces could sometimes be nibbled off by small fishes. Therefore, the discussion in this section focuses on those fish species large enough to potentially ingest these materials.

The analysis of ingestion impacts on fishes is structured around the following feeding strategies:

Feeding at or Just Below the Surface or Within the Water Column

- **Open-Ocean Predators.** Large, migratory, open-ocean fishes, such as salmon, tuna, dolphin fish, sharks, and billfishes, feed on fast-swimming prey in the water column of the Study Area (Table 3.6-17). These fishes range widely in search of unevenly distributed food patches. Atlantic salmon generally travel alone (Fay et al., 2006) but gather in common feeding areas near Greenland and Labrador, where they prey on schooling fish associated with the surface and water column of shallow open-water areas (Hansen & Windsor, 2006). Smaller military expended materials could be mistaken for prey items and ingested purposefully or incidentally as the fish is swimming. A few of these predatory fishes (e.g., bull sharks, tiger sharks) are known to ingest any type of marine debris that they can swallow, even automobile tires. Some marine fishes, such as the dolphinfish (*Coryphaena hippurus*) (South Atlantic Fishery Management Council, 2011) and tunas, eat plastic fragments, strings, nylon lines, ropes, or even small light bulbs (Choy & Drazen, 2013; Rochman et al., 2015).

Table 3.6-17: Ingestion Stressors Potential for Impact on Fishes Based on Location

Feeding Guild	*Representative Species*	*Endangered Species Act-Protected Species*	*Overall Potential for Impact*
Open-ocean predators	Dolphinfishes, most shark species, tuna, mackerel, wahoo, jacks, billfishes, swordfishes	Atlantic salmon, Scalloped hammerhead sharks, Oceanic whitetip sharks	These fishes may eat floating or sinking expended materials, but the encounter rate would be extremely low. May result in individual injury or death but is not anticipated to have population-level effects.
Open-ocean Plankton Eaters (Planktivores)	Atlantic herrings, Menhaden, basking shark, whale shark	Giant manta rays	These fishes may ingest floating expended materials incidentally as they feed in the water column, but the encounter rate would be extremely low. May result in individual injury or death but is not anticipated to have population-level effects.
Coastal bottom-dwelling predators	Atlantic cod, skates, cusks, and rays	Atlantic salmon, Scalloped hammerhead sharks, Nassau grouper	These fishes may eat expended materials on the seafloor, but the encounter rate would be extremely low. May result in individual injury or death but is not anticipated to have population-level effects.
Coastal bottom-dwelling foragers and scavengers	Skates and rays, flounders	Sturgeon species, Sawfish species	These fishes could incidentally eat some expended materials while foraging, especially in muddy waters with limited visibility. May result in individual injury or death but is not anticipated to have population-level effects.

Note: The scientific names of the listed species are as follows: Atlantic cod (*Hippoglossus hippoglossus*), Atlantic salmon (*Salmo salar*), basking shark (*Cetorhinus maximus*), cusk (*Brosme brosme*), dolphinfish (*Coryphaena hippurus*), whale shark (*Rhincodon typus*), rays (*Manta* spp.), and scalloped hammerhead shark (*Sphyrna lewini*), sawfish species (*Pristis* spp.), sturgeon species (*Acipenser* spp.), rays (*Manta* spp.), skates (*Amblyraja* spp.), and flounders (Bothidae).

- **Open-Ocean Planktivores.** Plankton-eating fishes in the open-ocean portion of the Study Area include herring, flying fishes, ocean sunfish, whale sharks, manta rays, and basking sharks. These fishes feed by either filtering plankton from the water column or by selectively ingesting larger zooplankton. These planktivores could encounter and incidentally feed on smaller types of military expended materials (e.g., chaff, end caps, pistons) at or just below the surface or in the water column (Table 3.6-2). Giant manta rays are the only ESA-listed species in the Study Area that is an open ocean planktivore, while some species in this group of fishes (e.g., herring) constitute a major prey base for many important predators, including salmon, tuna, sharks, marine mammals, and seabirds. While not a consumer of plankton, the ocean sunfish eats jellyfish and may consume a parachute/decelerator by accident at or just below the surface in the open ocean. Larger filter feeders such as whale sharks, basking sharks, and manta rays could also inadvertently ingest a parachute or decelerator.

Military expended materials that could potentially impact these types of fish at or just below the surface or in the water column include those items that float or are suspended in the water column for some period of time (e.g., decelerators/parachutes and end caps and pistons from chaff cartridges or flares).

Fishes Feeding at the Seafloor

- **Bottom Dwelling Predators.** Large predatory fishes near the seafloor are represented by species such as Atlantic cod and cusk, which are typical predators in the northern portion of the Study Area (Table 3.6-17). The cod and cusk feed opportunistically on or near the bottom, taking fishes and invertebrates from the water column (e.g., shrimp) and from the sediment (e.g., crabs) (Collette & Klein-MacPhee, 2002). The cod also ingests marine debris while feeding on or near the bottom. In the United Kingdom, plastic cups thrown from ferries have been discovered in cod stomachs (Hoss & Settle, 1990). The varied diet of the cod and the low visibility in its deep shelf habitat may promote the ingestion of foreign objects. The Atlantic salmon also feeds on fish on or near the seafloor such as sand lances and capelin. Cusks and sturgeon normally eats hard-shelled and spiny organisms, increasing the likelihood that it would swallow a sharp plastic or metal item rather than reject it.

- **Bottom Dwelling Foragers and Scavengers.** Bottom dwelling fishes in the nearshore coasts and estuaries may feed by seeking prey and by scavenging on dead fishes and invertebrates. All sturgeon in the Study Area suction-feed along the bottom in coastal waters on small fish and invertebrate prey, which increases the likelihood of incidental ingestion of marine debris (Ross et al., 2009).

Military expended materials that could be ingested by fishes at the seafloor include items that sink (e.g., small-caliber projectiles and casings, fragments from high-explosive munitions).

Potential impacts of ingestion on some adult fishes are different than for other life stages (eggs, larvae, and juveniles) because early life stages for some species are too small to ingest any military expended materials except for chaff, which has been shown to have limited effects on fishes in the concentration levels that it is released at (Arfsten et al., 2002; U.S. Air Force, 1997; U.S. Department of the Navy, 1999). Therefore, no ingestion potential impacts on early life stages would occur, with the exception of later stage juveniles that are large enough to ingest military expended materials.

Within the context of fish location in the water column and feeding strategies, the analysis is divided into (1) munitions (small- and medium-caliber projectiles, and small fragments from larger munitions, and flechettes); and (2) military expended material other than munitions (chaff, chaff end caps, compression pads or pistons, decelerators/parachutes, flares, and target fragments).

3.6.3.6.1 Impacts from Military Expended Materials – Munitions

Different types of explosive and non-explosive practice munitions are expended at sea during training and testing activities. This section analyzes the potential for fishes to ingest non-explosive practice munitions and fragments from high explosive munitions.

Types of non-explosive practice munitions generally include projectiles, missiles, and bombs. Of these, only small- or medium-caliber projectiles would be small enough for a large fishes to ingest. Small- and medium-caliber projectiles include all sizes up to and including 2.25 in. in diameter. These solid metal materials would quickly move through the water column and settle to the seafloor. Ingestion of non-explosive practice munitions in the water column is possible when shiny fragments of the munitions sink quickly and could be ingested by fast, mobile predators that chase moving prey (e.g., tunas, jacks, billfishes, swordfishes, dolphinfishes, mackerel, wahoo, and barracudas). In addition, these fragments may also be accidentally ingested by fishes that forage on the bottom such as sturgeon, flounders, skates, and rays.

Types of high explosive munitions that can result in fragments include demolition charges, projectiles, missiles, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the size of the net explosive weight and munitions type; however, typical sizes of fragments are unknown. These solid metal materials would quickly move through the water column and settle to the seafloor. Similar to non-explosive practice munitions described above, ingestion of high explosive munition fragments by fast-moving mobile predators such tunas, jacks, billfishes, swordfishes, dolphinfishes, mackerel, wahoo, and barracudas in the water column is possible, but unlikely. In the unlikely event that explosive material, high-melting-point explosive (known as HMX), or royal demolition explosive (known as RDX), is exposed on the ocean floor, it would break down in a few hours (U.S. Department of the Navy, 2001b). High-melting-point explosive or royal demolition explosive would not accumulate in the tissues of fish (Lotufo et al., 2010; Price et al., 1998). Fragments are primarily encountered by species that forage on the bottom.

It is possible that expended small caliber projectiles on the seafloor could be colonized by seafloor organisms and mistaken for prey or that expended small caliber projectiles could be accidentally or intentionally eaten during foraging. Over time, the metal may corrode or become covered by sediment in some habitats, reducing the likelihood of a fish encountering the small caliber, non-explosive practice munitions.

The potential impacts of ingesting foreign objects on a given fish depend on the species and size of the fish. Fishes that normally eat spiny, hard-bodied invertebrates may have tougher mouths and digestive systems than fish that normally feed on softer prey. Materials that are similar to the normal diet of a fish would be more likely to be ingested and more easily handled once ingested—for example, by fishes that feed on invertebrates with sharp appendages. These items could include fragments from high-explosives that a fish could encounter on the seafloor. Relatively small or smooth objects, such as small-caliber projectiles or their casings, might pass through the digestive tract without causing harm. A small sharp-edged item could cause a fish immediate physical distress by tearing or cutting the mouth, throat, or stomach. If the object is rigid and large (relative to the fish's mouth and throat), it may block the throat or obstruct the flow of waste through the digestive system. An object may be enclosed by a cyst in the gut lining (Danner et al., 2009; Hoss & Settle, 1990). Ingestion of large foreign objects could lead to disruption of a fish's normal feeding behavior, which could be sublethal or lethal.

3.6.3.6.1.1 Impacts from Military Expended Materials – Munitions under Alternative 1

Impacts from Military Expended Materials – Munitions under Alternative 1 for Training Activities

Use of military expended materials from munitions may occur throughout the AFTT Study Area. Fishes in the vicinity of these activities would have the remote potential to ingest military expended materials from munitions.

When these items explode, they may break apart or remain largely intact in irregularly shaped pieces—some of which may be small enough for some fishes to ingest. Some fishes such as sturgeon are able to feed on crustaceans that have hard, sharp, or irregular parts, without any impacts. Most fragments from high-explosives would be too large for a fish to ingest. Also, it is assumed that fragments from larger munitions are similar in size to fragments from smaller munitions. Although fragment size cannot be quantified, more individual fragments would result from larger munitions than from smaller munitions. The number of fragments that would result from the proposed explosions cannot be quantified. However, it is believed to be smaller than the number of small-caliber projectiles to be expended in the Study Area. Small-caliber projectiles would likely be more prevalent throughout the Study Area and more likely to be encountered and potentially ingested by bottom-dwelling fishes and some reef fishes, such as Nassau grouper, than fragments from any type of high-explosive munitions.

The Atlantic and Gulf sturgeon and smalltooth sawfish may occur in portions of the Study Area out to the continental shelf break where projectiles and munitions are used. Shortnose sturgeon can migrate long distances in coastal waters to their natal river or estuary (Wippelhauser et al., 2015), only occasionally moving to nearshore marine environments. The current Chesapeake Bay system population of shortnose sturgeon appears to be centered in the upper Chesapeake Bay (Welsh et al., 2002), outside of the Study Area. Training activities expending projectiles or munitions could expose sturgeon and sawfish to ingestion risk. These species could be injured if it ingested a small-caliber projectile or fragment and couldn’t pass it.

Scalloped hammerhead sharks could encounter some munitions-related material; although the likelihood is remote because only medium-caliber projectiles (no small-caliber projectiles) would be expended in the Key West Range Complex portion of the Study Area where this species would most likely occur. Although less likely, smalltooth sawfish could encounter some munitions-related material in the Jacksonville and Gulf of Mexico Range Complexes. Giant manta rays and oceanic whitetip sharks are generally surface-oriented feeders, with rays feeding on plankton in the upper water column, while oceanic whitetips are high-level predators feeding on fishes and cephalopods such as squid. It is unlikely that these species would mistake larger military expended materials in the water column for prey. If these species accidentally ingested military expended materials, it is likely that they would “taste” the item and then expel it, in the same manner that a fish would take a lure into its mouth then spit it out. It is also possible that giant mantas could ingest smaller fragments as they fall through the water column, although this species would be able to distinguish between a food item and non-food item such as fragments of military expended materials.

The likelihood of ingestion of munitions (or fragments) by early life stages of smalltooth sawfish would be slightly less than that of adults because nursery habitats are found in very shallow water (less than 1 m deep), where no munitions would be expended. Juvenile sturgeon are also found in the same freshwater rivers and tributaries as adults, including the James River, and would also be potentially exposed to ingestion stressors.

Overall, the potential impacts of ingesting munitions (whole or fragments) would be limited to individual fish that might suffer a negative response from a given ingestion event. While ingestion of munitions or fragments identified here could result in sublethal or lethal effects to a small number of individuals, the likelihood of a fish encountering an expended item is dependent on where that species feeds and the amount of material expended. Furthermore, an encounter may not lead to ingestion, As a fish might “taste” an item, then expel it (Felix et al., 1995), in the same manner that a fish would take a lure into its mouth then spit it out. The number of fishes potentially impacted by ingestion of munitions or fragments from munitions would be assumed to be low, and population-level effects would not be expected. The Navy will implement mitigation (e.g., not conducting gunnery activities within a specified distance of shallow-water coral reefs) to avoid potential impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for

Seafloor Resources). This mitigation will consequently help avoid potential impacts on fishes that inhabit shallow-water coral reefs.

Pursuant to the ESA, military expended materials such as munitions from training activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Military Expended Materials – Munitions under Alternative 1 for Testing Activities

Use of military expended materials from munitions may occur throughout the AFTT Study Area. Fish in the vicinity of these activities would have the potential to ingest military expended materials from munitions.

When these items explode, they may break apart or remain largely intact in irregularly shaped pieces—some of which may be small enough for a fish to ingest. Some fish species feed on crustaceans that have hard, sharp, or irregular parts, without any impacts. Most fragments from high-explosives would be too large for a fish to ingest. Also, it is assumed that fragments from larger munitions are similar in size to fragments from smaller munitions. Although fragment size cannot be quantified, more individual fragments would result from larger munitions than from smaller munitions. The number of fragments that would result from the proposed explosions cannot be quantified. However, it is believed to be smaller than the number of small-caliber projectiles to be expended in the Study Area. Small-caliber projectiles would likely be more prevalent throughout the Study Area and more likely to be encountered and potentially ingested by bottom-dwelling fishes than fragments from any type of high-explosive munitions. Furthermore, a fish might taste an item then expel it before swallowing it (Felix et al., 1995), in the same manner that fish would temporarily take a lure into its mouth, then spit it out. Based on these factors, the number of fishes potentially impacted by ingestion of munitions would be low and population-level impacts are not likely to occur.

The Atlantic and Gulf sturgeon and smalltooth sawfish may occur in portions of the Study Area out to the continental shelf break where projectiles and munitions are used. Shortnose sturgeon generally remain within their natal river or estuary, only occasionally moving to nearshore marine environments (Dadswell et al., 1984). The current Chesapeake Bay system population of shortnose sturgeon appears to be centered in the upper Chesapeake Bay (Welsh et al., 2002), outside of the Study Area. The likelihood of ingestion of munitions (or fragments) by early life stages of sawfishes would be slightly less than that of adults, because nursery habitats are found in very shallow water (less than 1 m deep), where no munitions would be expended. Early life stages of sturgeon are typically found in freshwater rivers and not in marine environments, so only sub-adults and adults would be potentially exposed to ingestion stressors.

As described above for training activities, giant manta rays and oceanic whitetip sharks are generally surface-oriented feeders. It is unlikely that these species would mistake larger military expended materials in the water column for prey, but if this occurred they accidentally ingested military expended materials, it is likely that they would “taste” the item and then expel it. Smaller fragments could be consumed and these species would be able to distinguish between food and non-food items.

Overall, the impacts on fishes ingesting munitions or fragments from munitions resulting from proposed testing activities would be low. The number of fishes potentially impacted by ingestion of munitions or fragments from munitions would be low, and population-level effects would not be expected. The Navy will implement mitigation (e.g., not conducting gunnery activities within a specified distance of shallow-water coral reefs) to avoid potential impacts from military expended materials on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources). This mitigation will consequently help avoid potential impacts on fishes that inhabit shallow-water coral reefs.

Pursuant to the ESA, military expended materials such as munitions from testing activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.6.1.2 Impacts from Military Expended Materials – Munitions under Alternative 2

Impacts from Military Expended Materials – Munitions under Alternative 2 for Training Activities

Because activities under Alternative 2 occur at the same rate and frequency relative to Alternative 1, ingestion stress experienced by fishes from military expended materials and munitions under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with training and testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended materials such as munitions from training activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

Impacts from Military Expended Materials – Munitions under Alternative 2 for Testing Activities

Because activities under Alternative 2 occur at the same rate and frequency relative to Alternative 1, ingestion stress experienced by fishes from military expended materials and munitions under Alternative 2 would be the same as those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended materials such as munitions from testing activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.6.1.3 Impacts from Military Expended Materials – Munitions under the No Action Alternative

Impacts from Military Expended Materials – Munitions under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Ingestion stressors for fishes from military expended materials such as munitions would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.6.2 Impacts from Military Expended Materials – Other Than Munitions

Fishes feed throughout the water column and could mistake many types of marine debris for prey items. Ingesting nonfood items is common among a variety of marine fishes, particularly those that feed on the seafloor (Boerger et al., 2010; Hoss & Settle, 1990; Jackson et al., 2000). Many fishes are also known to accidentally ingest plastic materials and the extent to which an individual fish might discriminate between a plastic item perceived as prey and an indistinct or less appealing shape is not clear. Once eaten, any type of plastic could cause digestive problems for the fish (Danner et al., 2009). Fishes have been reported to ingest a variety of materials or debris, such as plastic pellets, bags, rope, and line (Hoss & Settle, 1990; Jackson et al., 2000). As discussed above in Section 3.6.3.6 (Ingestion Stressors), some fish species such as the ocean sunfish eat jellyfish and may consume a parachute/decelerator at or just below the surface in the open ocean by accident. Larger filter feeders such as whale sharks, basking sharks, and manta rays could also inadvertently ingest a small or medium parachute or decelerator.

Chaff is used throughout the Study Area and is composed of an aluminum alloy coating on glass fibers of silicon dioxide and is released or dispensed in cartridges or projectiles that contain millions of fibers. Based on the small size of chaff fibers, fishes would likely not confuse the fibers with prey items or purposefully feed on them. However, some fishes could occasionally ingest low concentrations of chaff incidentally while feeding on prey items on the surface, in the water column, or the seafloor. Chaff fiber ingestion is not expected to impact fishes based on the low concentration that could reasonably be ingested and the small size of the chaff fibers. Therefore, exposure to chaff would cause no injury, mortality, or tissue damage to fishes. Potential impacts of chaff ingestion by fishes are not discussed further. Impacts of ingestion of the end caps, pistons, or compression pads associated with chaff cartridges are analyzed together with impacts of flares below.

Chaff end caps and pistons sink in saltwater (U.S. Department of the Navy, 1999). Fishes feeding on the seafloor where chaff canisters and flares are expended (e.g., range complexes, and testing ranges) would be more likely to encounter and ingest these items than in other locations. Ingested end caps or pistons could disrupt a fish's feeding behavior or digestive processes. If the item is particularly large relative to the fish ingesting it, the item could become permanently encapsulated by the stomach lining, and potentially lead to starvation and death (Danner et al., 2009 ; Hoss & Settle, 1990).

As described above, surface-feeding fishes have little opportunity to ingest end caps, pistons, or compression pads before they sink. However, some of these items could become entangled in dense *Sargassum* mats near the surface. Predatory open-ocean fishes, such as tuna, dolphinfishes, and billfishes, are attracted to the many small prey species associated with *Sargassum* mats. While foraging near the floating mats, predatory fishes may incidentally ingest end caps and pistons. The density of these items in any given location would vary based on release points and dispersion by wind and water currents. The number of end caps, pistons, or compression pads that would remain at or just below the surface in *Sargassum* mats and potentially available to fish is unknown. Unlike other plastic types of marine debris, end caps, pistons, and compression pads are heavier than water and not expected to float unless they are enmeshed in *Sargassum* or other floating debris.

Most materials associated with airborne mine neutralization system activities are recovered, but pieces of fiber optic cable may be expended (U.S. Department of the Navy, 2001a). For a discussion of the physical characteristics of these expended materials, where they are used, and the number of activities, please see Section 3.0.3.3.5.1 (Wires and Cables). Only small amounts of fiber optic cable would be deposited onto the seafloor each year, and the small amount of fiber optic cable expended during training and testing would sink to the seafloor. Pelagic fishes would be unlikely to encounter the small, dispersed lengths of fiber optic cable unless they were in the immediate area when the cable was expended. The low number of fiber optic cables expended in the Study Area during this activity makes it unlikely that fishes would encounter any fiber optic cables. Potential impacts of fiber optic cable ingestion by fishes are not discussed further.

As stated in Section 3.0.3.3.5.3 (Biodegradable Polymer), based on the constituents of the biodegradable polymer, it is anticipated that the material will breakdown into small pieces within a few days to weeks. These small pieces will breakdown further and dissolve into the water column within weeks to a few months and could potentially be incidentally ingested by fishes. Because the final products of the breakdown are all environmentally benign, the Navy does not expect the use of biodegradable polymer to have any negative impacts for fishes.

3.6.3.6.2.1 Impacts from Military Expended Materials – Other Than Munitions under Alternative 1

<u>Impacts from Military Expended Materials – Other Than Munitions under Alternative 1 for Training Activities</u>

As indicated in Section 3.0.3.3.6.3 (Military Expended Materials Other Than Munitions) under Alternative 1, activities involving target materials use would occur throughout the Study Area. All of the ESA-listed species occur where target materials could potentially be expended.

As indicated in Section 3.0.3.3.6.3 (Military Expended Materials Other Than Munitions), under Alternative 1, activities that expend chaff and flare occur throughout the Study Area. No potential impacts would occur from the chaff itself, but there is some potential for fishes to ingest the end caps, pistons, or compression pads associated with the chaff or flare cartridges.

Environmental concentrations would vary based on release points and dispersion by wind and water currents. The number of end caps and pistons that would remain at or just below the surface in *Sargassum* mats and potentially available to fish is unknown but is expected to be an extremely small percentage of the total.

ESA-listed species in the Key West Range Complex such as smalltooth sawfish and scalloped hammerhead sharks are bottom feeders and would not encounter end caps or flares at the surface, but could ingest an item after it settled to the bottom. However, these items would most likely pass through the digestive tract without causing harm. Based on the low density of expended endcaps and pistons, the encounter rate would be extremely low, and the ingestion rate even lower. No chaff or flares are planned for use in the Northeast Range Complexes where the Atlantic salmon occurs. The number of fishes potentially impacted by ingestion of end caps or pistons would be low based on the low environmental concentration. Population-level effects would not be expected.

As discussed above, it is unlikely that giant manta rays or oceanic whitetip sharks could mistake larger military expended materials other than munitions for prey, even though these species typically forage at or near the surface. If these species accidentally ingested military expended materials other than munitions, it is likely that they would "taste" the item and then spit it out. If these species accidentally ingested an item, it would most likely pass through the digestive tract without causing harm.

Overall, the potential impacts of ingesting decelerators/parachutes, target fragments, or end caps, pistons, or compression pads would be limited to individual fish that ingest an item too large to pass through its gut. Fishes encounter many items (natural and manmade) in their environment that are unsuitable for ingestion and most species have behavioral mechanisms for spitting out the item. If the item were swallowed, it could either pass through the digestive system without doing any harm, or become lodged inside the fish and cause injury or mortality.

For smalltooth sawfish, the likelihood of ingestion of military expended materials other than munitions by early life stages would be slightly less than that of adults, because nursery habitats are found in very shallow water (less than 1 m deep), where no military expended materials would occur. The potential impacts on smalltooth sawfish are discountable because they are historically rare in the locations where military expended materials are expended. Early life stages of sturgeon are typically found in freshwater rivers and not in marine environments, so only juveniles and adults would be potentially exposed to ingestion stressors.

Although ingestion of military expended materials identified here could result in sublethal or lethal effects, the likelihood of ingestion is low based on the dispersed nature of the materials, the limited encounter rate of fishes to the expended items, behavioral mechanisms for expelling the item, and the capacity of the fish's digestive system to simply pass the item through as waste. Based on these factors, the number of fishes potentially impacted by ingestion of military expended materials (such as chaff and flare end caps and pistons) would be low, and no population-level effects would be expected.

Pursuant to the ESA, military expended materials other than munitions from training activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

Impacts from Military Expended Materials – Other Than Munitions under Alternative 1 for Testing Activities

As indicated in Section 3.0.3.3.6.3 (Military Expended Materials Other Than Munitions) under Alternative 1, testing activities involving target materials use would occur throughout the Study Area. All of the ESA-listed species occur where target materials could potentially be expended.

As indicated in Section 3.0.3.3.6.3 (Military Expended Materials Other Than Munitions), under Alternative 1, activities involving chaff and flare use would occur in offshore locations throughout the Study Area. No potential impacts would occur from the chaff itself, but there is some potential for fishes, including ESA-listed species to ingest the end caps, pistons, or compression pads associated with the chaff or flare cartridges.

The smalltooth sawfish or sturgeon could ingest one of these items after it settled to the bottom, but the item would most likely pass through the digestive tract of a larger fish without causing harm, as the items measure only 1.3 in. (3.3 cm) in diameter and 0.13 in. (0.3 cm) in thickness. Based on the low density of expended end caps and pistons, the encounter rate would be extremely low, and the ingestion rate even lower. The number of fishes potentially impacted by ingestion of end caps or pistons would be low based on the low environmental concentration. Population-level effects would not be expected.

The potential impacts on smalltooth sawfish are discountable because they are historically rare in the locations where decelerators/parachutes, chaff, targets, and end-caps are expended. Smalltooth sawfish are rare in the Gulf of Mexico Large Marine Ecosystem, but since 1999, the species has been documented in the vicinity of the Naval Surface Warfare Center, Panama City Division Testing Range, and a viable population exists off the coast of southwest Florida (Papastamatiou et al., 2015).

For sawfishes, the early life stages have the same body-type as adults; however, the likelihood of ingestion of military expended materials other than munitions by early life stages would be slightly less than that of adults, because nursery habitats are found in very shallow water (less than 1 m), where no military expended materials would be expended. Early life stages of sturgeon are typically found in freshwater rivers and not in marine environments, so only juveniles and adults would be potentially exposed to ingestion stressors.

As discussed above, it is unlikely that offshore species such as giant manta rays or oceanic whitetip sharks could mistake larger military expended materials other than munitions for prey during testing activities, even though these species typically forage at or near the surface. It is likely that these species would “taste” and then spit it out if an item were accidentally ingested; if ingested, the item would most likely pass through the digestive tract without causing harm.

Overall, the risk of potential impacts of fishes ingesting military expended materials resulting from proposed testing activities would be low.

Pursuant to the ESA, military expended materials other than munitions from testing activities, as described under Alternative 1, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.6.2.2 Impacts from Military Expended Materials – Other Than Munitions under Alternative 2

Impacts from Military Expended Materials – Other Than Munitions under Alternative 2 for Training Activities

Because training activities under Alternative 2 occur at a similar rate and frequency relative to Alternative 1, ingestion stress experienced by fishes from military expended materials other than munitions under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with training activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended materials other than munitions from training activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

Impacts from Military Expended Materials – Other Than Munitions under Alternative 2 for Testing Activities

Because testing activities under Alternative 2 occur at a similar rate and frequency relative to Alternative 1, ingestion stress experienced by fishes from military expended materials other than munitions under Alternative 2 are not expected to be meaningfully different than those described under Alternative 1. Therefore, impacts associated with testing activities under Alternative 2 are the same as Alternative 1.

Pursuant to the ESA, military expended materials other than munitions from testing activities, as described under Alternative 2, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, and smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish.

3.6.3.6.2.3 Impacts from Military Expended Materials – Other Than Munitions under the No Action Alternative

Impacts from Military Expended Materials – Other Than Munitions under the No Action Alternative for Training and Testing Activities

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Ingestion stressors for fishes from military expended materials other than munitions would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.6.3.7 Secondary Stressors

This section analyzes potential impacts on fishes exposed to stressors indirectly through impacts on their prey availability and habitat (e.g., sediment or water quality, and physical disturbance). For the purposes of this analysis, indirect impacts on fishes via sediment or water which do not require trophic transfer (e.g., bioaccumulation) in order to be observed are considered here. It is important to note that the terms “indirect” and “secondary” do not imply reduced severity of environmental consequences, but instead describe how the impact may occur in an organism or its ecosystem.

Stressors from Navy training and testing activities could pose secondary or indirect impacts on fishes via habitat (e.g., sediment, and water quality) and prey availability. These include (1) explosives and explosion byproducts; (2) metals; (3) chemicals; and (4) other materials such as targets, chaff, and plastics. Activities associated with these stressors are detailed in Chapter 2 (Description of Proposed Action and Alternatives), and their potential effects are analyzed in Section 3.2 (Sediments and Water Quality), Section 3.4 (Invertebrates), and Section 3.5 (Habitats). The Navy will implement mitigation (e.g., not conducting gunnery activities within a specified distance of shallow-water coral reefs) to avoid potential impacts from explosives and physical disturbance and strike stressors on seafloor resources in mitigation areas throughout the Study Area (see Section 5.4.1, Mitigation Areas for Seafloor Resources).

This mitigation will consequently help avoid potential impacts on fishes that shelter in and inhabit on shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks.

3.6.3.7.1 Impacts on Habitat

The Proposed Action could result in localized and temporary changes to the benthic community during activities that impact fish habitat. Hard bottom is important habitat for many different species of fish, including those fishes managed by various fishery management plans. Fish habitat could become degraded during activities that would strike the seafloor or introduce military expended materials, bombs, projectiles, missiles, rockets, or fragments to the seafloor. The spatial area of habitat impacted by the Proposed Action would be relatively small compared to the available habitat in the Study Area. However, there would still be vast expanses of habitat adjacent to the areas of habitat impact that would remain undisturbed by the Proposed Action.

Explosions

Secondary impacts to fishes resulting from explosions at the surface, in the water column, or on the bottom would be associated with changes to habitat structure and effects to prey species. Most explosions on the bottom would occur in soft bottom habitat and would displace some amount of sediment, potentially resulting in cratering. However, water movement would redistribute the affected sediment over time. A small amount of sediment would be suspended in the water column temporarily (turbidity), but would resettle to the bottom. Activities that inadvertently result in explosions on or near hard bottom habitat or reefs could break hard structures and reduce the amount of colonizing surface available to encrusting organisms (e.g., corals, sponges). Given the large spatial area of the range complexes compared to the small percentage covered by hard bottom habitat, it is unlikely that most of the small, medium, and large projectiles expended in the Study Area would fall onto this habitat type. Furthermore, these activities are distributed within discrete locations within the Study Area, and the overall footprint of these areas is quite small with respect to the spatial extent of biogenic habitat within the Study Area.

Sinking exercises could also provide secondary impacts on deep-sea populations. These activities occur in open-ocean areas, outside of the coastal range complexes, with potential direct disturbance or strike impacts on deep-sea fishes, as covered in Section 3.6.3.1 (Acoustic Stressors). Secondary impacts on these fishes could occur after the ship hulks sink to the seafloor. Over time, the ship hulk would be colonized by marine organisms that attach to hard surfaces. For fishes that feed on these types of organisms, or whose abundances are limited by available hard structural habitat, the ships that are sunk during sinking exercises could provide an incidental beneficial impact on the fish community (Love & York, 2005; Macreadie et al., 2011).

The alternatives could result in localized and temporary changes to the benthic community during activities that impact fish habitat. Fish habitat could become degraded during activities that would strike the seafloor or introduce military expended materials, bombs, projectiles, missiles, rockets or fragments to the seafloor. During or following activities that impact benthic habitats, fish species may experience loss of available benthic prey at locations in the Study Area where these items might be expended. Additionally, plankton and zooplankton that are eaten by fishes may also be negatively impacted by these same expended materials. The spatial area of habitat impacted by the Proposed Action would be relatively small compared to the available habitat in the Study Area. However, there would still be vast expanses of habitat adjacent to the areas of habitat impact that would remain undisturbed by the Proposed Action.

Impacts of vessel disturbance and strike during amphibious assaults could temporarily reduce the quality and quantity of benthic substrate (sand) over an extremely localized and limited area within Onslow Beach and Seminole Beach. Fishes in the taxonomic group that includes the snapper-grouper complex (as managed by the South Atlantic Fishery Management Council), use these designated amphibious assault areas with sandy benthic substrate as habitat and could be impacted by this activity. However, the secondary habitat impacts on these fishes would be extremely localized compared to the total available area of sandy substrate available in the Jacksonville and Virginia Capes Range Complexes and the overall Study Area.

Impacts of physical disturbance and strikes by small-, medium-, and large-caliber projectiles would be concentrated within designated gunnery box areas, resulting in localized disturbances of hard bottom areas, but could occur anywhere in the range complexes or the Study Area. Hard bottom is important habitat for many different species of fish, including those fishes managed by various fishery management plans. The likelihood these habitats would be impacted is greater in Jacksonville and Navy Cherry Point Range Complexes compared to the Virginia Capes and Key West Range Complexes, based solely on these percentages. However, the location with the smallest proportion of hard bottom habitat (the Virginia Capes Range Complex) has the greatest concentration of small-caliber projectiles expended in the Study Area, with nearly 58 percent of the total small-caliber projectiles expended.

Explosion By-Products

Deposition of undetonated explosive materials into the marine environment can be reasonably well estimated by the known failure and low-order detonation rates of high-explosives. Undetonated explosives associated with munitions disposal and mine clearance are collected after training is complete; therefore, potential impacts are assumed to be inconsequential for these training and testing activities, but other activities could result in unexploded munitions and unconsumed explosives on the seafloor. Fishes may be exposed by contact with the explosive, 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 is rapidly diluted below threshold effect level. Explosion byproducts associated with high order detonations present no indirect stressors to fishes through sediment or water. However, low order detonations and unexploded munitions present elevated likelihood of impacts on fishes.

Indirect impacts of explosives and unexploded munitions to fishes via sediment is possible in the immediate vicinity of the munitions. Degradation of explosives proceeds via several pathways discussed in Section 3.2 (Sediments and Water Quality). Degradation products of royal demolition explosive are not toxic to marine organisms at realistic exposure levels (Rosen & Lotufo, 2010). Trinitrotoluene (TNT) and its degradation products impact developmental processes in fishes and are acutely toxic to adults at concentrations similar to real-world exposures (Halpern et al., 2008b; Rosen & 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 0.15–0.3 m away from degrading munitions, the concentrations of these compounds were not statistically distinguishable from background beyond 1–2 m from the degrading munitions (Section 3.2, Sediments and Water Quality). Taken together, it is likely that various life stages of fishes could be impacted by the indirect impacts of degrading explosives within a very small radius of the explosive (0.3–2 m).

If high-explosive munitions does not explode, it would sink to the bottom. In the unlikely event that explosive material, high-melting-point explosive (known as HMX), or royal demolition explosive (known as RDX) is exposed on the ocean floor, it would break down in a few hours (U.S. Department of the Navy, 2001a). High-melting-point explosive or royal demolition explosive would not accumulate in the tissues of fishes (Lotufo et al., 2010; Price et al., 1998). Fishes may take up trinitrotoluene (TNT) from the water when it is present at high concentrations but not from sediments (Lotufo et al., 2010). The rapid dispersal and dilution of trinitrotoluene (TNT) expected in the marine water column reduces the likelihood of a fish encountering high concentrations of trinitrotoluene (TNT) to near zero.

A series of research efforts focused on World War II underwater munitions disposal sites in Hawaii (Briggs et al., 2016; Edwards et al., 2016; Kelley et al., 2016; Koide et al., 2016; University of Hawaii, 2010) and an intensively used live fire range in the Mariana Islands (Smith & Marx, 2016) provide information in regard to the impacts of undetonated materials and unexploded munitions on marine life. A summary of this literature which investigated water and sediment quality impacts, on a localized scale, from munitions ocean disposal sites and ocean disposed dredge spoils sites is presented in the Sediment and Water Quality section and specifically in Section 3.2.3.1 (Explosives and Explosives Byproducts) and Section 3.2.3.3 (Metals). Findings from these studies indicate that there were no adverse impacts on the local ecology from the presence of degrading munitions and there was no bioaccumulation of munitions-related chemicals in local marine species. Therefore, water quality effects from the use of munitions, expended material, or devices would be negligible, would have no long-term effect on water quality, and therefore would not constitute a secondary indirect stressor for fishes.

Metals

Certain metals and metal-containing compounds at concentrations above background levels (e.g., cadmium, chromium, lead, mercury, zinc, copper, manganese, and many others) can be toxic to fishes (Wang & Rainbow, 2008). Metals are introduced into seawater and sediments as a result of training and testing activities involving vessel hulks, targets, munitions, batteries, and other military expended materials (Section 3.2, Sediments and Water Quality). Some metals bioaccumulate, and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals (U.S. Department of the Navy, 2012). Indirect effects of metals on fish via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. Fishes may be exposed by contact with the metal, contact with contaminants in the sediment or water, and ingestion of contaminated sediments. Concentrations of metals in seawater are orders of magnitude lower than concentrations in marine sediments. It is extremely unlikely that fishes would be indirectly impacted by toxic metals via the water.

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 are discussed in Section 3.2 (Sediments and Water Quality), but there is no additional risk to fishes because the Proposed Action does not introduce this chemical into the Study Area and the use of polychlorinated biphenyls has been nearly zero since 1979. Properly functioning flares, missiles, rockets, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment.

The greatest risk to fishes from flares, missiles, and rocket propellants is perchlorate which is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals. Fishes may be exposed by contact with contaminated water or ingestion of re-suspended contaminated sediments. Since perchlorate is highly soluble, it does not readily adsorb to sediments. Therefore, missile and rocket fuels pose no risk of indirect impact on fishes via sediment. In contrast, the principal toxic components of torpedo fuel, propylene glycol dinitrate, and nitrodiphenylamine, adsorb to sediments, have relatively low toxicity, and are readily degraded by biological processes (Section 3.2, Sediments and Water Quality). It is conceivable that various life stages of fishes could be indirectly impacted by propellants via sediment in the immediate vicinity of the object (e.g., within a few inches), but these potential impacts would diminish rapidly as the propellant degrades.

Other Materials

In some bottom types (without strong currents, hard-packed sediments, and low biological productivity), items such as projectiles might remain intact for some time before becoming degraded or broken down by natural processes. These potential impacts may cease only (1) when the military expended materials are too massive to be mobilized by typical oceanographic processes, (2) if the military expended materials become encrusted by natural processes and incorporated into the seafloor, or (3) when the military expended materials become permanently buried. In this scenario, a parachute could initially sink to the seafloor, but then be transported laterally through the water column or along the seafloor, increasing the opportunity for entanglement. In the unlikely event that a fish would become entangled, injury or mortality could result. In contrast to large decelerators/parachutes, other devices with decelerators such as sonobuoys are typically used in deep open ocean areas. These areas are much lower in fish numbers and diversity, so entanglement hazards are greatly reduced for commercially and recreationally targeted species (i.e., tuna, swordfishes, etc.), as well as mesopelagic prey of other species. The entanglement stressor would eventually cease to pose an entanglement risk as it becomes encrusted or buried.

Pursuant to the ESA, impacts on habitat from secondary stressors during training and testing activities, as described above, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.3.7.2 Impacts on Prey Availability

Impacts on fish prey availability resulting from explosives, explosives byproducts, unexploded munitions, metals, and chemicals would differ depending upon the type of prey species in the area, but would likely be negligible overall and have no population-level impacts on fishes. As discussed in Section 3.6.3.1 (Acoustic Stressors), fishes with swim bladders are more susceptible to blast injuries than fishes without swim bladders. During or following activities that impact benthic habitats, fish species may experience loss of available benthic prey at locations in the Study Area where these items might be expended. Additionally, plankton and zooplankton that are eaten by fishes may also be negatively impacted by these same expended materials some species of zooplankton that occur in the Pacific such as Pacific oyster (*Crassostrea gigas*) larvae have been found feeding on microplastics (Cole & Galloway, 2015).

In addition to physical effects of an underwater blast such as being stunned, 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 sound from underwater explosions might induce startle reactions and temporary dispersal of schooling fish if they are within close proximity (Popper et al., 2014; Wright, 1982).

The abundances of fish and invertebrate prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. The sound from underwater explosions might induce startle reactions and temporary dispersal of schooling fishes, potentially increasing visibility to predators, if they are within close proximity (Kastelein et al., 2008). Alternatively, any prey species that would be directly injured or killed by the blast could draw in scavengers from the surrounding waters that would feed on those organisms, and in turn could be susceptible to becoming directly injured or killed by subsequent explosions. Any of these scenarios would be temporary, only occurring during activities involving explosives, and no lasting impact on prey availability or the food web would be expected. Indirect impacts of underwater detonations and high explosive munitions use under the Proposed Action would not result in a decrease in the quantity or quality of fish populations in the Study Area.

Pursuant to the ESA, impacts on prey availability from secondary stressors during training and testing activities, as described above, would have no effect on designated critical habitat for Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, or smalltooth sawfish, but may affect Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, Nassau grouper, oceanic whitetip sharks, Central and Southwestern Atlantic Distinct Population Segment of scalloped hammerhead sharks, shortnose sturgeon, and smalltooth sawfish. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard. The Navy has consulted with the National Marine Fisheries Service, as required by section 7(a)(2) of the ESA in that regard.

3.6.4 Summary of Potential Impacts on Fishes

3.6.4.1 Combined Impacts of All Stressors under Alternative 1

As described in Section 3.0.3.5 (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 individual stressor are discussed in the analyses of each stressor in the sections above and summarized in Section 3.6.5 (Endangered Species Act Determinations).

There are generally two ways that a fish could be exposed to multiple stressors. The first would be if a fish were exposed to multiple sources of stress from a single activity (e.g., a mine warfare activity may include the use of a sound source and a vessel). The potential for a combination of these impacts from a single activity would depend on the range of effects of each stressor 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 fish were within the potential impact range of those activities, it may be impacted by multiple stressors simultaneously. This would be even more likely to occur during large-scale exercises or activities that span a period of days or weeks (such as a sinking exercises or composite training unit exercise).

A fish could also 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 fish frequent because it is within the animal's home range, migratory corridor, spawning or feeding area. Except for in the few concentration 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 fish would be exposed to stressors from multiple activities. However, animals with a home range intersecting an area of concentrated Navy activity have elevated exposure risks relative to animals that simply transit the area through a migratory corridor. The majority of the proposed 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 (on the order of a few hours or less).

Multiple stressors may also have synergistic effects. For example, fishes 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. Fishes that experience behavioral and physiological consequences of ingestion stressors could be more susceptible to entanglement and physical strike stressors via malnourishment and disorientation. These interactions are speculative, and without data on the combination of multiple Navy stressors, the synergistic impacts from the combination of Navy stressors are difficult to predict in any meaningful way. Navy research and monitoring efforts include data collection through conducting long-term studies in areas of Navy activity, occurrence surveys over large geographic areas, biopsy of animals occurring in areas of Navy activity, and tagging studies where animals are exposed to Navy stressors. These efforts are intended to contribute to the overall understanding of what impacts may be occurring overall to animals in these areas.

The combined impacts under Alternative 1 of all stressors would not be expected to impact fish populations because (1) activities involving more than one stressor are generally short in duration, and (2) such activities are dispersed throughout the Study Area. Existing conditions would not change considerably, therefore, no impacts on fish populations would occur with the implementation of Alternative 1.

3.6.4.2 Combined Impacts of All Stressors under Alternative 2

The combined impacts under Alternative 2 of all stressors would not be expected to impact fish populations because (1) activities involving more than one stressor are generally short in duration, and (2) such activities are dispersed throughout the Study Area. Existing conditions would not change considerably, therefore, no impacts on fish populations would occur after the implementation of Alternative 2.

3.6.4.3 Combined Impacts of All Stressors under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. The combined impacts of all stressors for fishes would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities and no impacts on fish population would occur.

3.6.5 Endangered Species Act Determinations

Pursuant to the ESA, the Navy has concluded training and testing activities may affect the Atlantic salmon, Atlantic sturgeon, giant manta ray, gulf sturgeon, Nassau grouper, oceanic whitetip shark, scalloped hammerhead shark, shortnose sturgeon, and smalltooth sawfish. The Navy has also concluded that training and testing activities may affect designated critical habitat for the Atlantic sturgeon and gulf sturgeon; and have no effect on designated critical habitat for the Atlantic salmon and smalltooth sawfish. The Navy has consulted with NMFS as required by section 7(a)(2) of the ESA in that regard. The Navy's summary of effects determinations for each ESA-listed species is shown in Table 3.6-18. Where the effects determinations reached by NMFS in their Biological Opinion differed from the Navy's, those differences are noted in a footnote to Table 3.6-18. NMFS determinations are made on the overall Proposed Action and are not separated by training and testing activities.

Table 3.6-18: Fishes Effect Determinations for Training and Testing Activities under Alternative 1 (Preferred Alternative)

Species	Designation Unit	Effect Determinations by Stressor																	
		Acoustic						Explosives	Energy		Physical Disturbance and Strike				Entanglement			Ingestion	
		Sonar and Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	In-water Electromagnetic Devices	High-energy Lasers	Vessels	In-water Devices	Military Expended Materials	Seafloor Devices	Wires and Cables	Decelerators/Parachutes	Biodegradable Polymer	Military Expended Materials - Munitions	Military Expended Materials - Other Than Munitions
Training Activities																			
Atlantic salmon	Gulf of Maine DPS	NLAA	N/A	NE	NLAA	NLAA	NLAA	LAA	NE	NE	NLAA	NLAA	NLAA	NE	NLAA	NLAA	N/A	NLAA	NLAA
	Critical habitat	NE	N/A	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	N/A	NE	NE
Atlantic sturgeon	Gulf of Maine DPS	NLAA	N/A	NLAA[2]	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	N/A	NLAA	NLAA
	New York Bight DPS	NLAA	N/A	NLAA[2]	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	N/A	NLAA	NLAA
	Chesapeake Bay DPS	NLAA	N/A	NLAA[2]	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	LAA	LAA	NLAA	NLAA	NLAA	LAA[1]	N/A	LAA[1]	LAA[1]
	Carolina DPS	NLAA	N/A	NLAA[2]	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	LAA	LAA	NLAA	NLAA	NLAA	LAA[1]	N/A	LAA[1]	LAA[1]
	South Atlantic DPS	NLAA	N/A	NLAA[2]	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	N/A	NLAA	NLAA
	Critical habitat	NE[1]	N/A	NE	NE[1]	NE	NE	NE	NE	NE	NE[1]	NE[1]	NE[1]	NLAA	NE	NE	N/A	NE	NE
Giant manta ray	Throughout range	NLAA	N/A	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	N/A	NLAA	NLAA
Gulf sturgeon	Throughout range	NLAA	N/A	NE	NLAA	NLAA	NLAA	LAA	NLAA	NE	LAA	LAA[1]	NLAA	NLAA	NLAA	NLAA	N/A	NLAA	NLAA
	Critical habitat	NE	N/A	NE	NE	NE	NE	NLAA	NE	NE	NE	NE	NE	NLAA	NE	NE	N/A	NE	NE

Table 3.6-18. Fishes Effect Determinations for Training and Testing Activities under Alternative 1 (Preferred Alternative) (continued)

Species	Designation Unit	Effect Determinations by Stressor																	
		Acoustic						Explosives	Energy		Physical Disturbance and Strike				Entanglement			Ingestion	
		Sonar and Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	In-water Electromagnetic Devices	High-energy Lasers	Vessels	In-water Devices	Military Expended Materials	Seafloor Devices	Wires and Cables	Decelerators/Parachutes	Biodegradable Polymer	Military Expended Materials - Munitions	Military Expended Materials - Other Than Munitions
Training Activities (continued)																			
Nassau grouper	Throughout range	NLAA	N/A	NE	NLAA	NE[1]	NE[1]	NLAA	NE	NE	NE[1]	NE[1]	NLAA	NLAA	NE	NLAA	N/A	NLAA	NLAA
Oceanic whitetip shark	Throughout range	NLAA	N/A	NE	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	N/A	NLAA	NLAA
Scalloped hammerhead shark	Central and Southwest Atlantic DPS	NLAA	N/A	NE	NLAA	NLAA	NLAA	LAA	NE	NE	NLAA	NLAA	NLAA	NLAA	NE	NLAA	N/A	NLAA	NLAA
Shortnose sturgeon	Throughout range	NLAA	N/A	NLAA	NLAA	NLAA	NE[1]	NLAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	N/A	LAA[1]	LAA[1]
Smalltooth sawfish	U.S. DPS	NLAA	N/A	NE	NLAA	NLAA	NE[1]	LAA	NLAA	NE[1]	NE	NE[1]	NLAA	NLAA	NLAA	NLAA	N/A	NLAA	NLAA
	Critical habitat	NE	N/A	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	N/A	NE	NE
Testing Activities																			
Atlantic salmon	Gulf of Maine DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NE[1]	NLAA	NLAA
	Critical habitat	NE	NE	N/A	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Table 3.6-18. Fishes Effect Determinations for Training and Testing Activities under Alternative 1 (Preferred Alternative) (continued)

Species	Designation Unit	Effect Determinations by Stressor																	
		Acoustic						Explosives	Energy		Physical Disturbance and Strike				Entanglement			Ingestion	
		Sonar and Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	In-water Electromagnetic Devices	High-energy Lasers	Vessels	In-water Devices	Military Expended Materials	Seafloor Devices	Wires and Cables	Decelerators/Parachutes	Biodegradable Polymer	Military Expended Materials - Munitions	Military Expended Materials - Other Than Munitions
Testing Activities (continued)																			
Atlantic sturgeon	Gulf of Maine DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
	New York Bight DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
	Chesapeake Bay DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
	Carolina DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
	South Atlantic DPS	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
	Critical habitat	NE[1]	NE	N/A	NE[1]	NE	NE	NE	NE	NE	NE[1]	NE[1]	NE[1]	NE[1]	NE	NE	NE	NE	NE
Giant manta ray	Throughout range	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	LAA[1]	NLAA	NLAA	NLAA
Gulf sturgeon	Throughout range	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
	Critical habitat	NE	NE	N/A	NE	NE	NE	NLAA	NE	NE	NE	NE	NE	NLAA	NE	NE	NE	NE	NE
Nassau grouper	Throughout range	NLAA	NE	N/A	NLAA	NE[1]	NE[1]	NLAA	NLAA	NE[1]	NE[1]	NE[1]	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA

Table 3.6-18. Fishes Effect Determinations for Training and Testing Activities under Alternative 1 (Preferred Alternative) (continued)

Species	Designation Unit	Effect Determinations by Stressor																	
		Acoustic						Explosives	Energy		Physical Disturbance and Strike				Entanglement			Ingestion	
		Sonar and Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosives	In-water Electromagnetic Devices	High-energy Lasers	Vessels	In-water Devices	Military Expended Materials	Seafloor Devices	Wires and Cables	Decelerators/Parachutes	Biodegradable Polymer	Military Expended Materials - Munitions	Military Expended Materials - Other Than Munitions
Testing Activities (continued)																			
Oceanic whitetip shark	Throughout range	NLAA	NLAA	N/A	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Scalloped hammerhead shark	Central and Southwest Atlantic DPS	NLAA	NE	N/A	NLAA	NLAA	NLAA	LAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Shortnose sturgeon	Throughout range	NLAA	NLAA	N/A	NLAA	NLAA	NE[1]	NLAA	NLAA	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Smalltooth sawfish	U.S. DPS	NLAA	NLAA	N/A	NLAA	NLAA	NE[1]	LAA	NLAA	NE[1]	NE	NE[1]	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
	Critical habitat	NE	NE	N/A	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Note: DPS= Distinct Population Segment; NE = no effect; NLAA = may effect, not likely to adversely affect; LAA = may effect, likely to adversely affect; N/A = not applicable, activity related to the stressor does not occur during specified training or testing events (e.g., there are no testing activities that involve the use of pile driving).
[1] Based on the analysis conducted in the Biological Opinion, NMFS reached the determination of NLAA.
[2] Based on the analysis conducted in the Biological Opinion, NMFS reached the determination of LAA.

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