NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL AND CONFERENCE OPINION

Title:	Biological and Conference Opinion on U.S. Navy Atlantic Fleet Training and Testing and the National Marine Fisheries Service's Promulgation of Regulations Pursuant to the Marine Mammal Protection Act for the Navy to "Take" Marine Mammals Incidental to Atlantic Fleet Training and Testing
Consultation Conducted By:	Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
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1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed) or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

The Federal action agency shall confer with the NMFS under ESA Section 7(a)(4) for species under NMFS jurisdiction on any action which is likely to jeopardize the continued existence of any proposed species or result in the destruction or adverse modification of proposed critical habitat (50 C.F.R. §402.10). If requested by the Federal agency and deemed appropriate, the conference may be conducted in accordance with the procedures for formal consultation in §402.14.

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, in accordance with the ESA Subsection 7(b)(3(A), NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures. NMFS, by regulation has determined that an ITS must be prepared when take is "reasonably certain to occur" as a result of the proposed action. 50 C.F.R. 402.14(g)(7).

The action agencies for this consultation are the United States (U.S.) Navy (Navy) and NMFS' Permits and Conservation Division (Permits Division). The Navy proposes to conduct Atlantic Fleet Training and Testing (AFTT) activities and the Permits Division proposes to promulgate regulations pursuant to the Marine Mammal Protection Act (MMPA) of 1972, as amended (16 U.S.C. 1361 et seq.) for the Navy to "take" marine mammals incidental to AFTT activities. The regulations propose the issuance of a Letter of Authorization (LOA) that will authorize the Navy to "take" marine mammals incidental to its proposed action, pursuant to the requirements of the MMPA.

This consultation, biological opinion, and ITS, were completed in accordance with section 7(a)(2) of the statute (16 U.S.C. 1536 (a)(2)), associated implementing regulations (50 C.F.R. Part 402), and agency policy and guidance by NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division (hereafter referred to as "we"). This biological opinion (opinion) and ITS were prepared by NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 C.F.R. Part 402 and specifically 50 CFR §402.14.

This document represents NMFS' opinion on the effects of the proposed AFTT actions and the Permits Division promulgation of regulations pursuant to the MMPA for the Navy to "take" marine mammals incidental to AFTT activities on endangered and threatened species and critical habitat that has been designated for those species. A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The Navy proposes to conduct training and testing activities within the AFTT Study Area (hereafter referred to as the "action area"; see Section 3.1 of this opinion for a description of the action area) starting in November 2018 and continuing into the reasonably foreseeable future. Navy training and testing activities have been ongoing in this same general geographic area for several decades and as indicated below, many of these activities have been considered in previous ESA section 7 consultations (i.e., as detailed below, in consultations that considered Phase I and Phase II Navy actions).

Between 2008 and 2013, NMFS issued multiple biological opinions on Navy training and testing activities proposed in the Atlantic Ocean and Gulf of Mexico. In general, these consultations considered training or testing activities in a relatively small geographic location, such as a specific range complex (e.g., research, development, testing, and evaluation activities at U.S. Naval Surface Warfare Center, Panama City, Florida; training activities in the Virginia Capes, Cherry Point, and Jacksonville Range Complexes), or considered a specific type of exercise over a larger geographic area (e.g., Atlantic Fleet Active Sonar Training along the Atlantic Coast and in the Gulf of Mexico). Where incidental take of marine mammals was anticipated, these consultations also considered NMFS Permits Division's promulgation of regulations and issuance of LOAs pursuant to the MMPA for the Navy to "take" marine mammals incidental to their activities. Each of these opinions concluded that the Navy and NMFS Permits Division's proposed actions would not jeopardize the continued existence of threatened or endangered species or destroy or adversely modify designated critical habitat. Collectively, NMFS and the Navy referred to the activities that were the subject of these consultations as Phase I.[1]

On November 14, 2013, NMFS issued a biological opinion on proposed Phase II Atlantic Fleet training and testing activities starting in November 2013 and the associated MMPA authorization of incidental take of marine mammals by the NMFS Permits Division from November 2013 to November 2018. For the consultation on Phase II activities, the Navy grouped many of the same training and testing activities considered in previous stand-alone consultations into a single proposed action. The opinion concluded that the Navy and NMFS' Permits Division's proposed actions would not jeopardize the continued existence of threatened or endangered species or destroy or adversely modify designated critical habitat.

1.2 Consultation History

Our communication with the Navy and NMFS' Permits Division regarding this consultation is summarized as follows:

- In April 2016, as part of the technical assistance stage for the Phase III AFTT consultation, NMFS requested the Navy consider expanding the geographic mitigation areas for North Atlantic right whales in the Northeast and Southeast.
- On December 2, 2016, NMFS continued technical assistance by provided comments to the Navy on the AFTT Phase III Draft Environmental Impact Statement (DEIS), Version 2.
- On March 20, 2017, the Navy provided NMFS a proposal for expanded Northeast and Southeast North Atlantic right whale mitigation areas (See Section 3.4.2.2) over those established in Phase II, which included an analysis of how the extent of this expansion was balanced against the requirement to support military readiness activities. The proposed expanded mitigation areas were incorporated into the Navy's proposed action for Phase III AFTT activities in November 2017 and are part of the proposed action description in Section 3 of the opinion.
- In May 2017, NMFS continued technical assistance by providing comments to the Navy on the AFTT Phase III DEIS, Version 3.
- On August 18, 2017, the Navy requested NMFS review of a draft Biological Assessment (BA) for Phase III AFTT activities.
- On October 4, 2017, NMFS provided comments on the draft BA to the Navy.
- On December 15, 2017, the Navy requested initiation of formal consultation for Phase III AFTT activities and submitted an initiation package including a BA.

[1] Note: Since this was the first set of MMPA incidental take regulations, ESA biological opinions, and National Environmental Policy Act Environmental Impact Statements for Navy At-Sea training and testing activities, these activities were referred to as Phase I activities. Subsequent phases are referred to as Phase II, Phase III, etc.

- On January 24, 2018, NMFS requested information regarding the pile driving analysis described in the AFTT BA, specifically regarding accumulation periods for vibratory and impact hammers, and weighting functions for marine mammals.
- On March 13, 2018, NMFS' Permits Division issued a proposed rule to authorize the take of marine mammals incidental to Phase III AFTT activities. On March 16, 2018, NMFS Permits Division requested initiation of formal consultation with NMFS' ESA Interagency Cooperation Division on the proposed rule.
- On April 5, 2018, the Navy provided some of the additional information requested regarding marine mammal pile driving analysis.
- On April 6, 2018, the Navy provided NMFS updated information regarding analysis for scalloped hammerhead sharks, and new language regarding seafloor devices and analysis of fiber optic cables.
- On April 11, 2018, NMFS sent the Navy a description of additional mitigation measures to further reduce potential adverse impacts of the proposed action on ESA-listed marine mammals, including North Alantic right whales and requested the Navy incorporate these additional mitigation measures into their proposed action.
- On April 12, 2018, NMFS and Navy met to discuss the additional mitigation measures proposed by NMFS.
- On April 22, 2018, NMFS requested additional information from the Navy regarding the potential effects of AFTT activities on ESA-listed corals.
- On May 2, 2018, the Navy provided a response to NMFS regarding effects of the action on ESA-listed corals.
- On May 14, 2018, Navy provided a written response to NMFS' request that additional mitigation measures be incorporated in the proposed action in order to reduce potential adverse impacts on ESA-listed marine mammals, including North Atlantic right whales.
- On May 31, 2018, NMFS Permits Division submitted to the Navy three additional mitigation and monitoring proposals for consideration.
- On June 1, 2018, NMFS and Navy met via teleconference to discuss the additional mitigation and monitoring measures proposed by NMFS Permits Division.
- On June 1, 2018, NMFS ESA Interagency Cooperation Division determined that Navy and NMFS Permits Division had provided sufficient information to initiate formal consultation.
- On June 6, 2018, Navy provided a written response to NMFS Permits Division's proposal for additional mitigation and monitoring.
- On June 8, 2018, NMFS provided a draft biological opinion to the Navy.
- On June 19, 2018, Navy provided comments to NMFS on the draft biological opinion.
- Between June 29 and August 1, 2018 Navy and NMFS communicated via teleconference and email regarding the comments Navy submitted on the draft biological opinion.

Topics of discussion included the ITS, effects analysis for ESA-listed corals, marine mammal and sea turtle ship strike analysis, pile driving analysis for ESA-listed fishes, and NMFS' effects determinations.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 C.F.R. §402.02.

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of an ESA-listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (50 C.F.R. §402.02).

An ESA section 7 assessment involves the following steps:

1) We describe the proposed action (Section 3) the action area (Section 4), and any interrelated or interdependent actions (Section 5) related to the proposed action.

2) We deconstruct the action into the activities such that we can identify those aspects of the proposed action that are likely to create pathways for adverse impacts to ESA-listed species or designated critical habitat. These pathways or "stressors" may have direct or indirect effects on the physical, chemical, and biotic environment within the action area. We also consider the spatial and temporal extent of those stressors (Section 6).

3) We identify the ESA-listed species and designated critical habitat that are likely to co-occur with those stressors in space and time (Section 7). During consultation, we determined that some ESA-listed species that occur in the action area were not likely to be adversely affected by the proposed action. We summarize our findings and do not carry those species forward in this opinion (Section 7.1). We describe the status of species that are likely to be adversely affected (Section 7.2).

4) We describe the environmental baseline in the action area (Section 8) including: past and present impacts of Federal, state, or private actions and other human activities in the action area; anticipated impacts of proposed Federal projects that have already undergone formal or

early section 7 consultation, and impacts of state or private actions that are contemporaneous with the consultation in process.

5) We evaluate the direct and indirect effects of an action on ESA-listed species or designated critical habitat, together with the effects of other activities that are interrelated or interdependent with that action (Section 9).

    a) During our evaluation, we determined that some stressors were not likely to adversely affect some ESA-listed species, categories of ESA-listed species, or designated critical habitat; we summarize those findings in Section 9.1.

    b) The stressors that are likely to adversely affect ESA-listed species were carried forward for additional analysis (Section 9.2). For these stressors, we evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. This is our response analyses.

    c) We identify the number, age (or life stage), and gender if possible and if needed, of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong. This is our exposure analysis.

    d) We assess the consequences of these responses of individuals that are likely to be exposed to the populations those individuals represent, and the species those populations comprise. This is our risk analysis.

    e) The adverse modification analysis considers the impacts of the proposed action on the essential habitat features and conservation value of designated critical habitat using the same exposure, response, and risk framework.

6) We describe any cumulative effects of the proposed action in the action area (Section 10).

7) We integrate and synthesize the above factors (Section 11) by considering the effects of the action to the environmental baseline and the cumulative effects to determine whether the action would reasonably be expected to:

    a) Reduce appreciably the likelihood of both survival and recovery of the ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or

    b) Reduce the conservation value of designated or proposed critical habitat.

8) We state our conclusions regarding jeopardy and the destruction or adverse modification of designated critical habitat (Section 12).

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative to the action that would allow the action to proceed in compliance with ESA section 7(a)(2). The reasonable and prudent alternative also must meet other regulatory requirements.

If incidental take of ESA-listed species is expected, section 7(b)(4) requires that we provide an ITS that specifies the amount or extent of take, the impact of the take, reasonable and prudent measures to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures (ESA section 7 (b)(4); 50 C.F.R. §402.14(i); Section 13). ESA section (7)(o)(2) provides that compliance by the action agency with the terms and conditions exempts any incidental take from the prohibitions of take in ESA section 9(b) and regulations issued pursuant to ESA section 4(d).

"Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. NMFS has not yet defined "harass" under the ESA in regulation. However, on December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as an action that "creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering" (NMFS 2016b). For purposes of this consultation, we relied on NMFS' interim definition of harassment to evaluate when the proposed activities are likely to harass ESA-listed species. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

We also provide discretionary conservation recommendations that may be implemented by action agency. 50 C.F.R. §402.14(j). Finally, we identify the circumstances in which reinitiation of consultation is required. 50 C.F.R. §402.16.

2.1 Evidence Available for this Consultation

To conduct these analyses and to comply with our obligation to use the best scientific and commercial data available, we considered all lines of evidence available through published and unpublished sources that represent evidence of adverse consequences or the absence of such consequences. We conducted electronic literature searches throughout this consultation, including within NMFS Office of Protected Resource's electronic library. We examined the Navy's BA, the Navy's Environmental Impact Statement (EIS), the literature that was cited in the Navy's BA and EIS, and any articles we collected through our electronic searches. We also evaluated the Navy's annual and comprehensive monitoring reports required under the existing MMPA rule and LOAs and the previous biological opinion for current training and testing activities occurring in the same geographic area. These resources were used to identify information relevant to the potential stressors and responses of ESA-listed species and designated critical habitat under NMFS' jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species and the value of designated critical habitat for the conservation of ESA-listed species. In addition, we engage regularly with the Navy to discuss new science and technical issues as part of the ongoing adaptive management program for Navy training and testing and incorporate new information obtained as a result of these engagements in this consultation.

As is evident later in this opinion, many of the stressors considered in this opinion involve sounds produced during Navy training and testing. Considering the information that was available, this consultation and our opinion includes uncertainty about the basic hearing capabilities of some marine mammals, sea turtles, and fishes; how these taxa use sounds as environmental cues; how they perceive acoustic features of their environment; the importance of sound to the normal behavioral and social ecology of species; the mechanisms by which human-generated sounds affect the behavior and physiology (including the non-auditory physiology) of exposed individuals; and the circumstances that are likely to produce outcomes that have adverse consequences for individuals and populations of exposed species.

The sections below discuss NMFS' approach to analyzing the effects of sound produced by Navy training and testing activities in the AFTT action area on ESA-listed marine mammals, sea turtles, and fish. The estimates of the number of ESA-listed marine mammals and sea turtles exposed to sound from Navy training and testing, as well as the magnitude of effect from each exposures (e.g., injury, hearing loss, behavioral response), are from the Navy's acoustic effects analysis described in detail in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts on Marine Mammals and Sea Turtles* (Navy 2018b). NMFS considers the modeling conclusions from the Navy's analysis to represent the best available data on exposure of marine mammals and sea turtles to acoustic stressors from the proposed action. [1] NMFS' analysis of the effects of and potential consequences of such exposures is included in Section 9 of this opinion.

2.2 United States Navy's Acoustic Effects Analysis for Marine Mammals and Sea Turtles

Acoustic stressors include acoustic signals emitted into the water for a specific purpose (e.g., by active sonars and air guns), as well as incidental sources of broadband sound produced as a byproduct of vessel movement, aircraft transits, pile driving and removal, and use of weapons or other deployed objects. Explosives also produce broadband sound but are characterized separately from other acoustic sources due to their unique energetic characteristics. To estimate

[1] The Navy's acoustic effects analysis did not estimate the number of instances ESA-listed fish or corals that could be affected by acoustic stressors from the proposed action.

impacts from acoustic stressors associated with proposed training and testing activities, the Navy performed a quantitative analysis to estimate the number of instances that could affect ESA-listed marine mammals and sea turtles and the magnitude of that effect (e.g., injury, hearing loss, behavioral response). The quantitative analysis utilizes the Navy's Acoustic Effects Model (NAEMO) and takes into account criteria and thresholds used to predict impacts in conjunction with spatial densities of species within the action area.

A summary of the quantitative analysis is provided below. A detailed explanation of this analysis is in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts on Marine Mammals and Sea Turtles* (Navy 2018b). NMFS verified the methodology and data used by the Navy in this analysis and unless otherwise specified in Section 9 of this opinion, accepted the modeling conclusions on exposure of marine mammals and sea turtles to sound generated by the proposed action. NMFS considers the modeling conclusions from the Navy's analysis to represent the best available data on exposure of marine mammals and sea turtles to acoustic stressors from the proposed action and the estimates of take resulting from this analysis are reasonably certain to occur. The modeling conclusions for marine mammals from this analysis were also the basis for the Navy's take authorization request under the MMPA.

2.2.1 Criteria and Thresholds to Predict Impacts to Marine Mammals and Sea Turtles

The Navy's quantitative acoustic effects analysis for marine mammals and sea turtles relies on information about the numerical sound and energy values that are likely to elicit certain types of physiological and behavioral reactions. The following section describes the specific criteria developed and applied for each species and sound source associated with Navy training and testing activities.

For marine mammals, the Navy, in coordination with the NMFS, established acoustic thresholds (for impulsive, non-impulsive sounds and explosives) using the best available science that identifies the received level of underwater sound above which exposed marine mammals would reasonably be expected to experience a potentially significant disruption in behavior, or to incur temporary threshold shifts (TTS) or permanent threshold shifts (PTS) of some degree. Thresholds have also been developed to identify the pressure levels above which animals may incur different types of tissue damage from exposure to pressure waves from explosive detonation. Non-auditory injury (i.e., other than PTS) and mortality from sonar and other transducers is considered so unlikely as to be discountable under normal conditions and is therefore not considered further in this opinion for marine mammals.[1] Non-auditory injury from Navy air guns and pile driving is also considered so unlikely as to be discountable. A detailed

[1] Non-auditory injury from sonar is not anticipated due to the lack of fast rise times, lack of high peak pressures, and the lack of high acoustic impulse of sonar. Note that non-auditory injury is possible from impulsive sources such as explosions.

description of the criteria and threshold development is included in the technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017b). The thresholds used by the Navy were developed by compiling and synthesizing the best available science on the susceptibility of marine mammals and sea turtles to effects from acoustic exposure.

2.2.1.1 Marine Mammal Criteria for Hearing Impairment, Non-Auditory Injury, and Mortality

The marine mammal criteria and thresholds for non-impulsive and impulsive sources for hearing impairment, non-auditory injury, and mortality, as applicable, are described below. The Navy's quantitative acoustic effects analysis used dual criteria to assess auditory injury (i.e., PTS) to different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from two different types of sources (impulsive [explosives, air guns, impact pile driving] and non-impulsive [sonar, vibratory pile driving]). The criteria used in the analysis are described in *NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal* Hearing (NOAA 2018). The Technical Guidance also identifies criteria to predict TTS, which is not considered injury.

The Navy used auditory weighting and exposure functions to assess the varying susceptibility of marine mammals to effects from noise exposure. Animals are not equally sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions were used (Figure 1). Auditory weighting functions are mathematical functions that adjust received sound levels to emphasize ranges of best hearing and de-emphasize ranges with less or no auditory sensitivity. They incorporate species-specific hearing abilities to calculate a weighted received sound level in units sound pressure level (SPL) or sound exposure level (SEL). They resemble an inverted "U" shape with amplitude plotted as a function of frequency. The flatter portion of the plotted function, where the amplitude is closest to zero, is the emphasized frequency range, while the frequencies below and above this range (where amplitude declines) are de-emphasized.

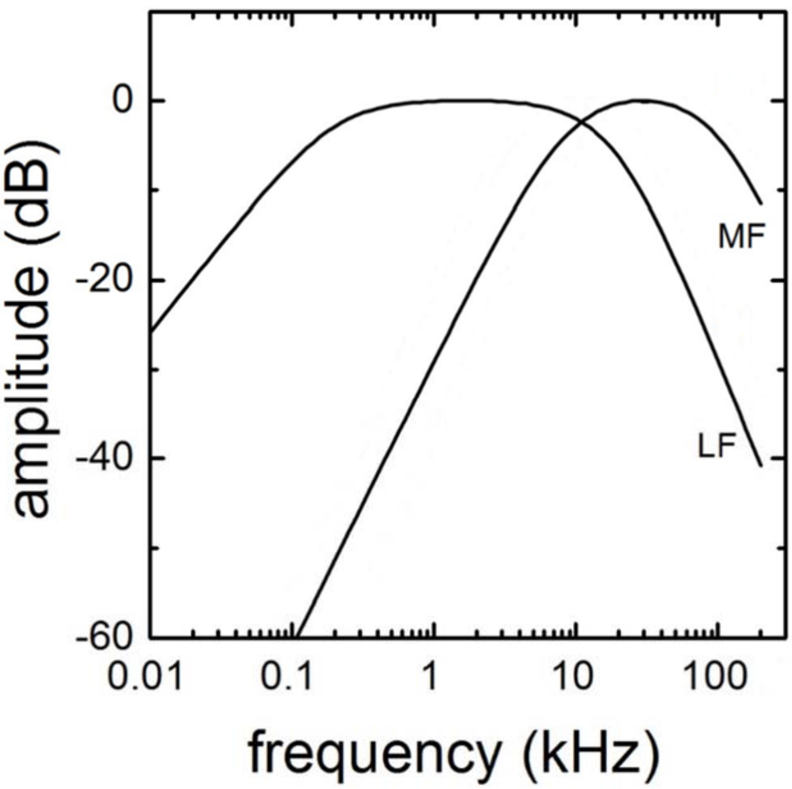
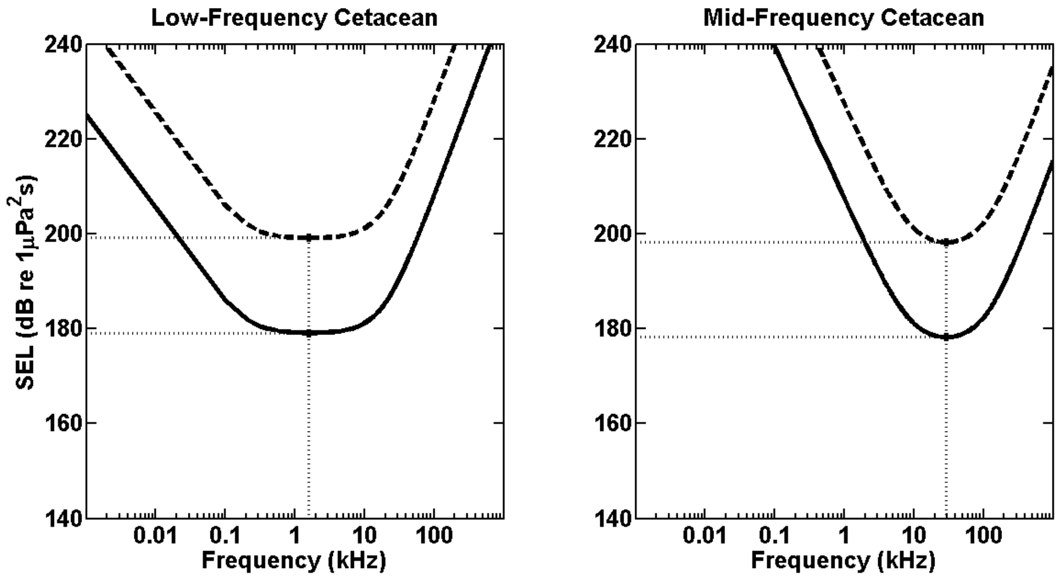


Figure 1. The auditory weighting function for low (LF) and mid (MF) frequency cetaceans. For parameters used to generate the functions and more information on weighting function derivation, see Navy (2017a).

For non-impulsive sources, the TTS and PTS exposure functions for marine mammals are presented in Figure 2.



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

Figure 2. TTS and PTS exposure functions for sonar and other acoustic sources (Navy 2017a).

Based on the exposure functions, the marine mammal thresholds for non-impulsive acoustic sources are summarized in Table 1.

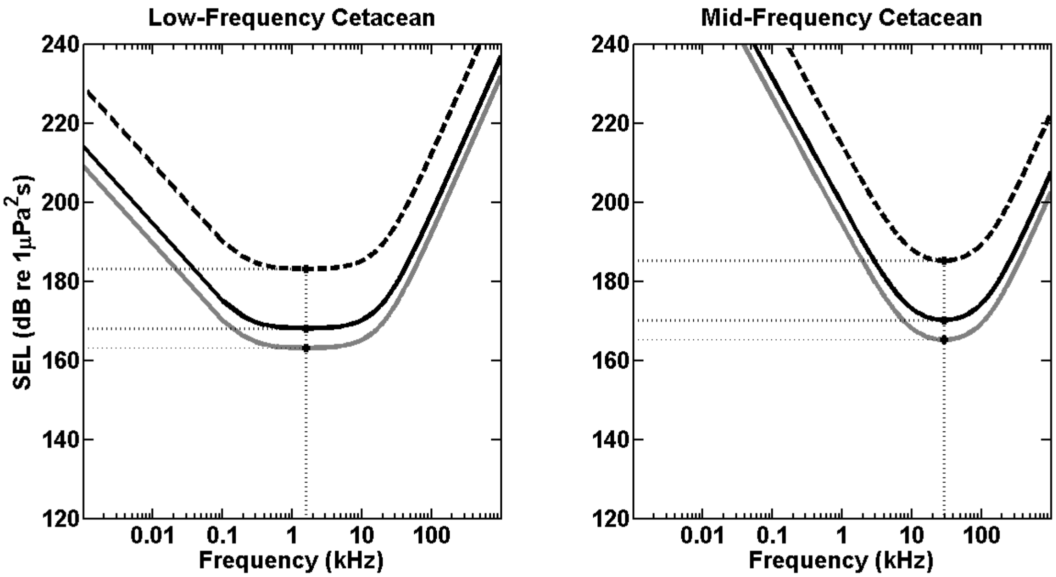
Table 1. Acoustic thresholds identifying the onset of temporary threshold shift (TTS) and permanent threshold shift (PTS) for non-impulsive sound sources by functional hearing group Navy (2017a).

Functional Hearing Group	TTS Threshold (SEL [weighted])	PTS Threshold (SEL [weighted])
Low-Frequency Cetaceans	179	199
Mid-Frequency Cetaceans	178	198
Phocid Pinnipeds (Underwater)	181	201

Note: Sound Exposure Level (SEL) thresholds in decibels (dB) re 1 μPa²s.

For impulsive sources (inclusive of explosives, air guns, and impact pile driving), the TTS and PTS exposure functions for marine mammals are presented in Figure 2.[1]

[1] Note that this figure also depicts the marine mammal exposure functions for behavioral response from explosives. Additional information on explosives criteria for marine mammals is presented in section 2.2.1.2.3.



Note: The dark dashed curve is the exposure function for PTS onset, the solid black curve is the exposure function for TTS onset, and the light grey curve is the exposure function for behavioral response. Small dashed lines indicate the SEL threshold for behavioral response, TTS, and PTS onset at each group's most sensitive frequency (i.e., the weighted SEL threshold).

Figure 3. Behavioral, TTS, and PTS exposure functions for explosives (Navy 2017a).

Based on the exposure functions, the marine mammals onset TTS and PTS thresholds for impulsive sources are described in Table 2.

Table 2. Onset of TTS and PTS in marine mammals for explosives, air guns, and impact pile driving.

Functional Hearing Group	Species	Onset TTS	Onset PTS
Low-frequency cetaceans	All mysticetes	168 dB SEL (weighted) or 213 dB Peak SPL (unweighted)	183 dB SEL (weighted) or 219 dB Peak SPL (unweighted)
Mid-frequency cetaceans	Sperm whales	170 dB SEL (weighted) or 224 dB Peak SPL (unweighted)	185 dB SEL (weighted) or 230 dB Peak SPL (unweighted)
Phocidae	Ringed seals	170 dB SEL (weighted) or 212 dB Peak SPL (unweighted)	185 dB SEL (weighted) or 218 dB Peak SPL (unweighted)

Notes: TTS = Temporary threshold shift; PTS = Permanent threshold shift; dB = decibel, SEL = sound exposure level; SPL = sound pressure level

Unlike the other acoustic sources proposed for use by the Navy, explosives also have the potential to result in non-auditory injury or mortality. Two metrics have been identified as predictive of injury: impulse and peak pressure. Peak pressure contributes to the "crack" or "stinging" sensation of a blast wave, compared to the "thump" associated with received impulse. Two sets of thresholds are provided for use in non-auditory injury assessment. The exposure thresholds are used to estimate the number of animals that may be affected during Navy training and testing activities (See second column of Table 3). The thresholds for the farthest range to effect are based on the received level at which one percent risk is predicted and are useful for informing mitigation zones (See third column of Table 3). Increasing animal mass and increasing animal depth both increase the impulse thresholds (i.e., decrease susceptibility), whereas smaller mass and decreased animal depth reduce the impulse thresholds (i.e., increase susceptibility). For masses used in impact assessment, marine mammal populations are assumed to be 70 percent adult and 30 percent calf/pup. The derivation of these injury criteria and the species mass estimates are provided in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (Navy 2017b).

Table 3. Criteria to quantitatively assess marine mammal non-auditory injury due to underwater explosions (second column) and criteria for estimating ranges to potential effect for mitigation purposes (third column).

Impact Category	Exposure Threshold	Threshold for Farthest Range to Effect*
Mortality (Impulse)	$144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$	$103M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$
Injury (Impulse)	$65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$	$47.5\ {}^{1}/_{3}\ 1\ +\frac{D}{.\ 1})^{1/6}$ Pa-s
Injury (Peak Pressure)	243 dB re 1 μPa SPL peak	237 dB re 1 μPa SPL peak

** Threshold for one percent risk used to assess mitigation effectiveness.*
Notes: dB re 1 μPa: decibels referenced to 1 micropascal; Pa-s: pascal second; SPL: sound pressure level; D: depth of animal (m); M: mass of animal (kilograms).

2.2.1.2 Marine Mammal Criteria for Behavioral Response

Many of the behavioral responses estimated using the Navy's quantitative analysis are most likely to be of moderate severity (defined for the purposes of this impact analysis as reaction levels 4, 5, and 6 based on the behavioral response severity scale described in Southall et al. (2007a). Moderate severity responses would be considered significant if they were sustained for a duration long enough that they cause variations in an animal's daily behavior outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. Within the Navy's quantitative analysis, many behavioral reactions are predicted from exposure to sound that may exceed an animal's behavioral threshold momentarily. It is likely that some of the resulting estimated behavioral harassment takes would not constitute a significant disruption of normal behavior patterns. The Navy and NMFS have used the best available science to address the challenging differentiation between significant and non-significant behavioral reactions, but have erred on the side of caution where uncertainty exists (i.e., counting shorter duration behavioral reactions as take). This likely results in some degree of overestimation of the number of significant behavioral disruptions. Therefore, this analysis includes the maximum number of potential behavioral disturbances and responses that are reasonably certain to occur.

The following sections describe the criteria and thresholds used in the analysis for each acoustic source.

2.2.1.2.1 Impulsive and Non-Impulsive Sound Sources (Air Guns and Pile Driving) – Marine Mammals

Though significantly driven by received level, the onset of behavioral disturbance from anthropogenic noise exposure is informed to varying degrees by other factors related to the source (e.g., frequency, predictability, duty cycle), the environment (e.g., bathymetry), and the receiving animals (hearing, motivation, experience, demography, behavioral context) and can be difficult to predict (Ellison et al. 2011; Southall et al. 2007a). Given the best available science and the practical need to use a threshold based on a factor that is both predictable and measurable for most activities, since 1997, NMFS has used generic sound exposure thresholds (i.e., not specific to a particular hearing group) to determine whether an activity produces underwater sounds (e.g., air guns or pile driving) that might result in behavioral disturbance of marine mammals (70 FR 1871). NMFS and the Navy used the following behavioral disturbance thresholds, expressed in root mean square (rms), for air guns and pile driving:

- Impulsive sound (e.g., impact pile driving and air guns): 160 decibel (dB) rms referenced to one microPascal (re 1μPa)
- Non-impulsive sound (e.g., vibratory pile driving): 120 dBrms (re 1 μPa)

2.2.1.2.2 Sonar – Marine Mammals

For Phase III activities, the Navy coordinated with NMFS to develop behavioral harassment criteria specific to the military readiness activities that utilize active sonar. The derivation of these criteria is discussed in detail in *The Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles Technical Report* (Navy 2017b). Developing the criteria for sonar involved multiple steps. All available behavioral response studies conducted both in the field and on captive animals were examined in order to understand the breadth of behavioral responses of marine mammals to sonar and other transducers. Marine mammal species were placed into behavioral criteria groups based on their known or suspected behavioral sensitivities to sound. In most cases, these divisions were driven by taxonomic classifications (*e.g*., mysticetes, odontocetes). The data from the behavioral studies were analyzed by looking for significant disruptions of normal behavior patterns (e.g., breeding, feeding, sheltering), or lack thereof, for each experimental session. Due to the nature of behavioral response research to date, it is not currently possible to ascertain the types of observed reactions that would lead to an abandonment or significant alteration of a natural behavior pattern. Therefore, a methodology was developed to estimate the possible significance of behavioral reactions and impacts on normal behavior patterns.

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

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

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

For the derivation of behavioral criteria, a significant duration was defined as a response that lasted for the duration of exposure or longer, regardless of how long the exposure session may have been. This assumption was made because it was not possible to tell if the behavioral responses would have continued if the exposure had continued. The costs associated with these observed behavioral reactions were not measured so it is not possible to judge whether reactions would have risen to the level of significance as defined above, although it was conservatively assumed the case.

Marine mammal species were placed into behavioral criteria groups based on their known or suspected behavioral sensitivities to sound (Figure 4 and Figure 5). These divisions are driven by taxonomic classifications (e.g., mysticetes, odontocetes).

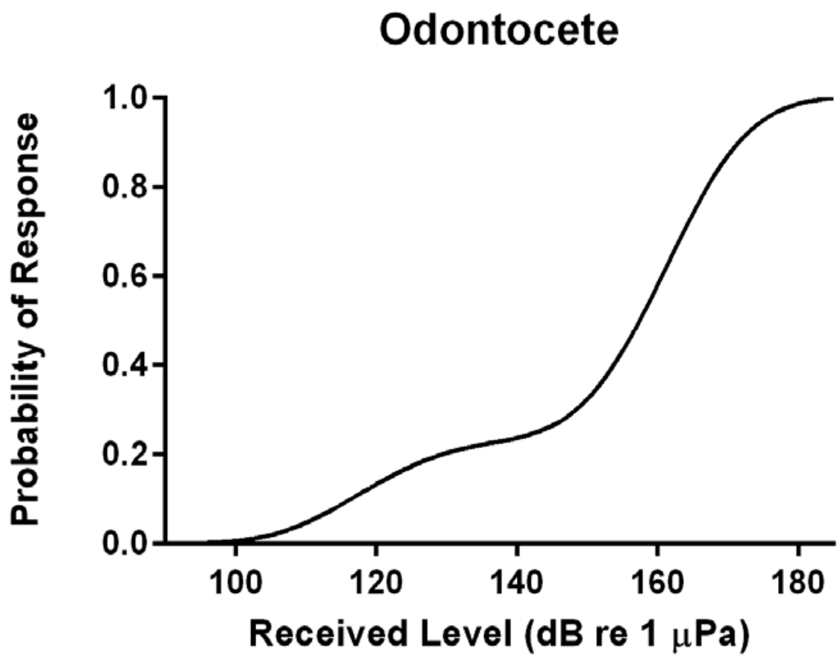


Figure 4. Behavioral response function for odontocetes (Navy 2017b).

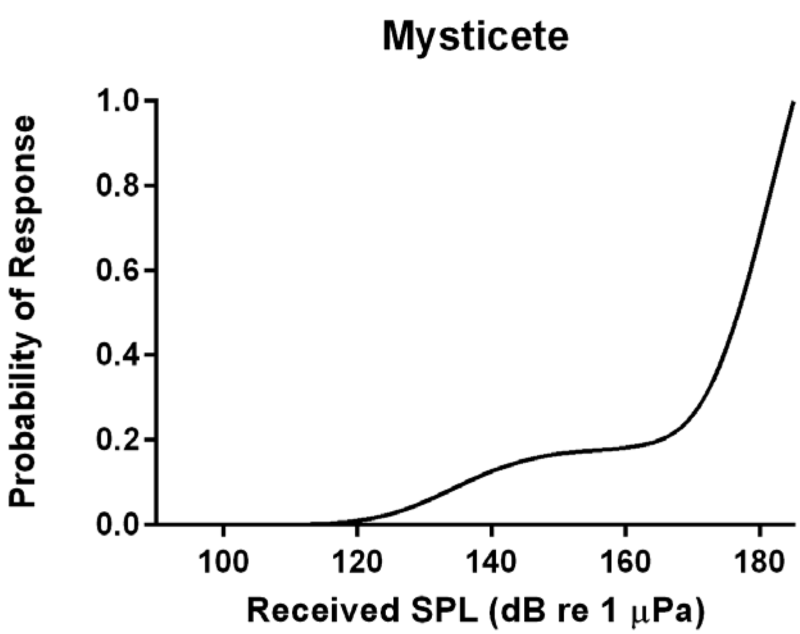


Figure 5. Behavioral response function for mysticetes (Navy 2017b).

The analysis for active sonar used cutoffs distances beyond which recent research suggests the potential for significant behavioral disruptions (and therefore harassment under the ESA) is considered to be unlikely (Table 4). For animals within the cutoff distance, a behavioral response function based on a received SPL was used to predict the probability of a potential significant behavioral response. For training and testing events that contain multiple platforms or tactical sonar sources that exceed 215 dB re 1 μPa @ 1 m, this cutoff distance is substantially increased (*i.e.*, doubled) from values derived from the literature. The use of multiple platforms and intense sound sources are factors that are expected to increase responsiveness in marine mammals overall. There are currently few behavioral observations under these circumstances. For this reason, and to be conservative in the analysis of potential effects, the Navy predicted significant behavioral responses at further ranges for these more intense activities.

Table 4. Cutoff distances for moderate source level, single platform training and testing events and events with multiple platforms or sonar with relatively high sources levels[1] (Navy 2017b).

Species Group	Moderate Source Level / Single Platform Cutoff Distance	High Source Level / Multi-Platform Cutoff Distance
Odontocetes	10 km	20 km
Pinnipeds	5 km	10 km
Mysticetes	10 km	20 km

[1]Relatively high sources levels are defined as levels at or exceeding 215 dB 1 μPa at 1 m.
Note: km = kilometers

2.2.1.2.3 Explosives Criteria – Marine Mammals

Phase III explosive criteria for behavioral thresholds for marine mammals is the hearing group's TTS threshold minus 5 dB (See Table 2 above for the TTS thresholds for explosives) for events that contain multiple impulses from explosives underwater. Significant behavioral responses to solitary explosions are not anticipated due to the short duration of acoustic exposure from such explosions.

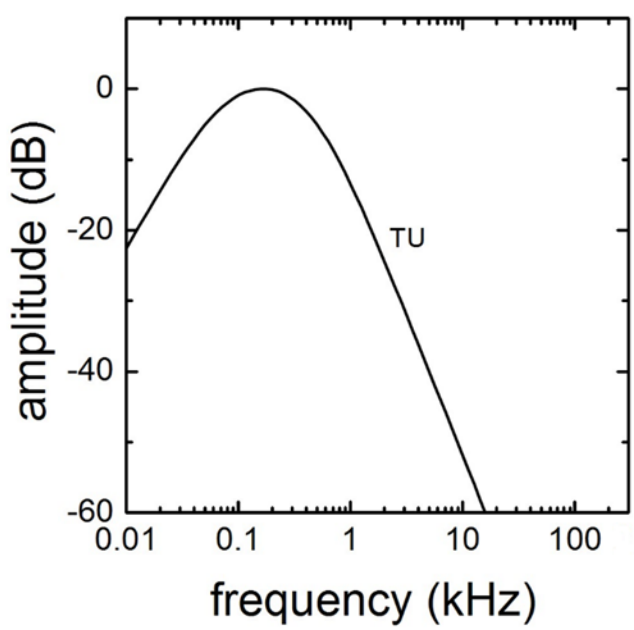
Table 5. Phase III behavioral thresholds for explosives for marine mammals underwater (Navy 2017b).

Functional Hearing Group	Sound Exposure Level (weighted)
Low-frequency cetaceans	163
Mid-frequency cetaceans	165
Phocid pinnipeds	165

Note: Weighted SEL thresholds in dB re 1 μPa^{2}s underwater

2.2.1.3 Hearing Impairment Criteria – Sea Turtles

In order to develop some of the hearing thresholds of received sound sources for sea turtles, expected to produce TTS and PTS, the Navy compiled all sea turtle audiograms available in the literature in an effort to create a composite audiogram for sea turtles as a hearing group. Measured or predicted auditory threshold data, as well as measured equal latency contours, were used to influence the weighting function shape for sea turtles. For sea turtles, the weighting function parameters were adjusted to provide the best fit to the experimental data. The same methods were then applied to other species for which TTS data did not exist. However, because these data were insufficient to successfully model a composite audiogram via a fitted curve as was done for marine mammals, median audiogram values were used in forming the sea turtle hearing group's composite audiogram. Based on this composite audiogram and data on the onset of TTS in fishes, an auditory weighting function was created to estimate the susceptibility of sea turtles to hearing loss or damage. This auditory weighting function for sea turtles is shown in Figure 6, and is described in detail in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis* (Phase III) (Navy 2017b). The frequencies around the top portion of the function, where the amplitude is closest to zero, are emphasized, while the frequencies below and above this range (where amplitude declines) are de-emphasized, when summing acoustic energy received by a sea turtle.



Notes: dB = decibels, kHz = kilohertz, TU = sea turtle species group

Figure 6. Auditory weighting function for sea turtles (Navy 2017b).

2.2.1.4 Impulsive Sound Sources (Air Guns and Pile Driving) – Sea Turtles

In order to estimate exposure of ESA-listed sea turtles to impulsive sound sources such as air guns and pile driving), we relied on acoustic thresholds for PTS and TTS for impulsive sounds developed by Navy for Phase III activities. As described above, very limited information exists regarding hearing and sea turtles. To date, no studies have been conducted specifically related to the onset of TTS or PTS in sea turtles. Therefore, the thresholds used were developed from the most current literature on sea turtle hearing and recommendations made by Popper et al. (2014), in Sound Exposure Guidelines for Fishes and Sea Turtles ("2014 American National Standards Institute [ANSI] Guidelines") that developed thresholds for fishes and sea turtles (Popper et al. 2014). Moreover, the Navy's approach employs the same statistical methodology to derive thresholds as in NMFS' recently issued technical guidance for auditory injury of marine mammals (NOAA 2018). The derivation of the auditory weighting function and sea turtle audiogram are described above.

Based on this composite audiogram and data on the onset of TTS in fishes, an auditory weighting function was created to estimate the susceptibility of sea turtles to TTS. Data from fishes were used since there are currently no data on TTS for sea turtles and fishes are considered to have hearing more similar to sea turtles than do marine mammals (Popper et al. 2014). Assuming a similar relationship between TTS onset and PTS onset as has been described for humans and the available data on marine mammals, an extrapolation to PTS susceptibility of sea turtles was made based on the methods proposed by (Southall et al. 2007a). From these data and analyses, dual metric thresholds were established similar to those described for marine mammals and fishes, including a peak sound pressure level metric (0-pk SPL) that does not incorporate the auditory weighting function nor the duration of exposure, and another based on cumulative sound exposure level (SEL_{cum}) that incorporates both the auditory weighting function and the exposure duration (Table 6).

Table 6. Acoustic thresholds identifying the onset of PTS and TTS for sea turtles exposed to impulsive sounds (Navy 2017b).

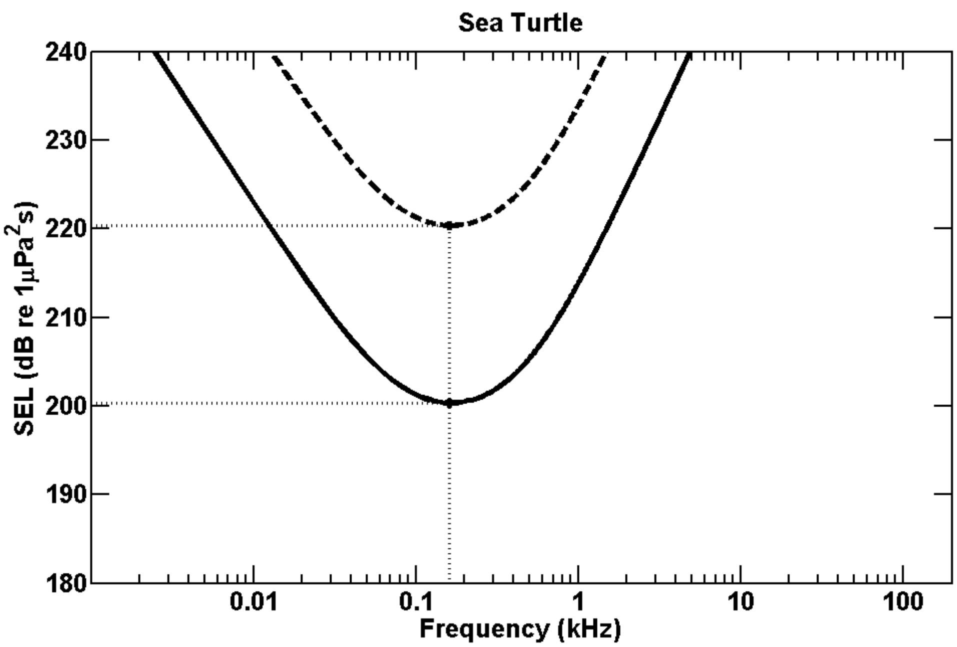
Hearing Group	Generalized Hearing Range	Permanent Threshold Shift Onset (weighted)	Temporary Threshold Shift Onset (weighted)
Sea Turtles	30 Hz to 2 kHz	204 dB re 1 $\mu Pa^2 \cdot s$ SEL_{cum} 232 dB re: 1 μPa SPL (0-pk)	189 dB re 1 $\mu Pa^2 \cdot s$ SEL_{cum} 226 dB re: 1 μPa SPL (0-pk)

Hz = hertz

In order to estimate exposure of ESA-listed sea turtles to sound fields generated by impulsive sound sources that would be expected to result in a behavioral response, we (and the Navy per our request) relied on the available scientific literature. Currently, the best available data come from studies by O'Hara and Wilcox (1990a) and Mccauley et al. (2000a), who experimentally examined behavioral responses of sea turtles in response to seismic air guns. O'Hara and Wilcox (1990a) found that loggerhead turtles exhibited avoidance behavior at estimated sound levels up to 175 dB_{rms} (re: 1 μPa), in a shallow canal. McCauley et al. (2000c) reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB re: 1 μPa (rms). At 175 dB re: 1 μPa (rms), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (Mccauley et al. 2000a). Based on these data, we assume that sea turtles would exhibit a behavioral response when exposed to received sound pressure levels of 175 dB_{rms} (re: 1 μPa) and higher.

2.2.1.5 Sonar Criteria – Sea Turtles

As mentioned above, no studies have been conducted specifically related to sea turtle hearing loss. The Navy evaluated sea turtle susceptibility to hearing loss (from sonar exposure) based upon what is known about sea turtle hearing abilities in combination with non-impulsive auditory effect data from other species such as marine mammals and fishes. This approach allows for the development of sea turtle exposure functions, shown below in Figure 7. These mathematical functions relate the sound exposure levels for onset of PTS or TTS to the frequency of the sonar sound. A full description of how the Navy derived these functions is provided in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (Navy 2017b). Based upon this approach, sea turtle onset of TTS would be expected to occur if received sound levels exceed 200 dB, SEL_{cum} (re: 1 μPa^2-s) and PTS would occur for sounds that exceed 220 dB SEL_{cum} (re: 1 μPa^2-s) at an exposure frequency of 200 hertz (Hz).



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

Figure 7. TTS and PTS exposure functions for sonar and other transducers (Navy 2017a).

To date, very little research has been done regarding sea turtle behavioral responses relative to sonar exposure. Because of this, the working group that prepared the *2014 ANSI Guidelines* (Popper et al. 2014) provide descriptors of sea turtle behavioral responses to sonar and other transducers. The working group estimated that the risk of a sea turtle responding to a low-frequency sonar (less than 1 kilohertz [kHz]) is low regardless of proximity to the source, and that there is no risk of a sea turtle responding to a mid-frequency sonar (1 to 10 kHz). However, for this analysis, similar to impulsive sounds, NMFS requested that the Navy estimate the number of sea turtles that could be exposed to sonar within their hearing range at received levels of 175 dB re: 1 μPa SPL (rms) or greater. This level is based upon work by Mccauley et al. (2000a), described for air guns. Sound levels that exceed this could cause sea turtles to exhibit a significant behavioral response such as erratic and increased swimming rates and avoidance of the sound source. Because data on sea turtle behavioral responses to non-impulsive sounds, such as sonars, is limited, the air gun data set is used to inform potential risk. We recognize this is a conservative approach, and that the relative risk of a sea turtle responding to air guns would likely be higher than the risk of responding to sonar; so it is likely that potential sea turtle behavioral responses to sonar exposures are a sub-set of sea turtles exposed to received levels of 175 dB rms (re: 1 μPa) or greater.

2.2.1.6 Explosives Criteria – Sea Turtles

As with all other species groups, NMFS and the Navy apply dual metric criteria to assess the potential onset of physical injury and hearing impairment from explosives for sea turtles. These criteria include both the peak pressure and the sound exposure level. Similar to other marine species, the sound pressure or blast wave produced from a detonation does not only affect hearing, but may also induce other physical injuries such as external damage to the carapace, and internally to organs and blood vessels. For sea turtles, the Navy developed criteria to determine the potential onset of hearing loss, physical injury (non-auditory) and non-injurious behavioral response to detonation exposure using the weighting function and hearing group described above, as well as the impulsive sound threshold criteria recommended by the 2014 *ANSI Guidelines* (Popper et al. 2014). The derivation of these injury criteria (and the species mass estimates) are described in the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* technical report (Navy 2017b).

The dual metric criteria for non-auditory injury are provided in Table 7. These thresholds also include the farthest range to effect, based on the received level at which a one percent risk is predicted and are useful for assessing the effectiveness of mitigation measures (described in greater detail later). In order to evaluate the degree to which a sea turtle may be susceptible to injury from the blast energy of an explosive detonation, both the size of the sea turtle as well as depth of the animal in the water column at exposure must be considered. This is because a larger sea turtle located deeper in the water column is assumed to be less susceptible to impacts than a smaller sea turtle, located closer to the surface in the water column. In addition, the Navy divided the percentage of the sea turtle populations according to age classes that are most likely to comprise the populations present in the action area for their impact assessment. The Navy assumed five percent of the population would be adult, and the remaining 95 percent of individuals to be sub-adult. This ratio is estimated from what is currently known about the population age structure for sea turtles based upon egg clutch size, early juvenile survival rates and survival rates for sub-adult and adult turtles. In general, sea turtles typically lay multiple clutches of 100 or more eggs, have low juvenile survival rates, but those that make it past early life stages increase survival at later life stages. Based upon these factors, the following thresholds and range to farthest effects are as follows:

Table 7. Criteria to quantitatively assess non-auditory injury due to underwater explosions for sea turtles (Navy 2017a).

Impact Category	Exposure Threshold	Threshold for Farthest Range to Effect*
Mortality (Impulse)	$144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$	$103M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$
Injury (Impulse)	$65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$	$47.5\ {}^{1}/_{3}\ 1\ +\ \frac{D}{.\ \ 1}\Big)^{1/6}$ Pa-s
Injury (Peak Pressure)	243 dB re 1 µPa SPL peak	237 dB re 1 µPa SPL peak

** Threshold for one percent risk used to assess mitigation effectiveness.*
Notes: dB re 1 µPa: decibels referenced to 1 micropascal; Pa-s: pascal second; SPL: sound pressure level; D: depth of animal (m); M: mass of animal (kilograms).

For hearing loss, the same thresholds applied for impulsive sound sources and sonar are also used for explosives and provided above in Table 6. Similarly, for behavioral response assessment, NMFS requested that the Navy estimate the number of sea turtles that could be exposed to explosions at received sound pressure levels of 175 dB_{rms} (re 1 µPa) or greater. This is the level at which Mccauley et al. (2000a) determined sea turtles would begin to exhibit avoidance behavior after multiple firings of nearby or approaching air guns.

2.2.2 Density Estimates – Marine Mammals and Sea Turtles

Below we provide a summary on the methods used to derive the marine mammal and sea turtle density estimates used in the Navy's acoustic exposure analysis.[1] Additional details on the density data used for these analyses are provided in the Navy Marine Species Density Database (NMSDD) (Navy 2017e).

For most cetacean species, abundance is estimated using line-transect surveys or mark-recapture studies (e.g., Barlow 2010; Barlow and Forney 2007). The result provides one single density estimate value for each species across broad geographic areas. This is the general approach

[1] As noted above, the Navy did not estimate the number of instance of exposure to ESA-listed fish species due to a lack of density data for this species group in the action area.

applied in estimating cetacean abundance in NMFS' marine mammal stock assessment reports. Although the single value provides a good average estimate of abundance (total number of individuals) for a specified area, it does not provide information on the species distribution or concentrations within that area, and it does not estimate density for other timeframes or seasons that were not surveyed. More recently, habitat modeling has been used to estimate cetacean densities (Barlow et al. 2009; Becker et al. 2012a; Becker et al. 2010; Becker et al. 2012b; Ferguson et al. 2006; Forney et al. 2012; Redfern et al. 2006). These models estimate cetacean density as a continuous function of habitat variables (e.g., sea surface temperature, seafloor depth, etc.) and thus allow predictions of cetacean densities on finer spatial scales than traditional line-transect or mark recapture analyses. Within the geographic area that was modeled, densities can be predicted wherever these habitat variables can be measured or estimated.

To characterize the marine species density for large areas such as the AFTT action area, the Navy compiled data from several sources. The Navy developed a protocol to select the best available data sources based on species, area, and time (season). The resulting Geographic Information System database called the Navy Marine Species Density Database includes seasonal density values for every marine mammal species present within the AFTT action area. This database is described in the technical report titled *U.S. Navy Marine Species Density Database Phase III for the Atlantic Fleet Training and Testing Area* (Navy 2017e), hereafter referred to as the density technical report.

A variety of density data and density models are needed in order to develop a density database that encompasses the entirety of the AFTT action area. Because this data is collected using different methods with varying amounts of accuracy and uncertainty, the Navy has developed a model hierarchy to ensure the most accurate data is used when available. The density technical report describes these models in detail and provides detailed explanations of the models applied to each species' density estimate. The below list describes possible models in order of preference.

1. Spatial density models (See Roberts et al. 2016) predict spatial variability of animal presence based on habitat variables (e.g., sea surface temperature, seafloor depth, etc.). This model is developed for areas, species, and, when available, specific timeframes (months or seasons) with sufficient survey data. Therefore, this model cannot be used for species with low numbers of sightings. In the AFTT action area, this model is available for certain species along the east coast within the offshore extent of available survey data, and in the Gulf of Mexico.
2. Design-based density models predict animal density based on survey data. Like spatial density models, they are applied to areas with survey data. Design-based density models may be stratified, in which a density is predicted for each sub-region of a survey area, allowing for better prediction of species distribution across the density model area. In the

AFTT action area, stratified density models are used for certain species on both the east coast and the Gulf of Mexico. In addition, a few species' stratified density models are applied to areas east of regions with available survey data and cover a substantial portion of the Atlantic Ocean portion of the AFTT action area.

3. Extrapolative models are used in areas where there is insufficient or no survey data. These models use a limited set of environmental variables to predict possible species densities based on environmental observations during actual marine mammal surveys (See Mannocci et al. 2017). Because some unsurveyed areas have oceanographic conditions that are very different from surveyed areas (e.g., the Labrador Sea and North Atlantic gyre) and some species models rely on a very limited data set, the predictions of some species' extrapolative density models and some regions of certain species' extrapolative density models are considered highly speculative. In the AFTT action area, extrapolative models are typically used east of regions with available survey data and cover a substantial portion of the Atlantic Ocean of the AFTT action area. Extrapolative models are not used in the Gulf of Mexico.
4. Existing Relative Environmental Suitability models include a high degree of uncertainty, but are applied when no other model is available. The majority of the world's oceans have not been surveyed in a manner that supports quantifiable density estimation of marine mammals and sea turtles. In the absence of empirical survey data, information on known or inferred associations between marine habitat features and (the likelihood of) the presence of specific species have been used to predict densities using model-based approaches. These habitat suitability models include Relative Environmental Suitability models. Habitat suitability models can be used to understand the possible extent and relative expected concentration of a marine species distribution. These models are derived from an assessment of the species occurrence in association with evaluated environmental explanatory variables that results in defining the Relative Environmental Suitability of a given environment. A fitted model that quantitatively describes the relationship of occurrence with the environmental variables can be used to estimate unknown occurrence in conjunction with known habitat suitability. Abundance can thus be estimated for each Relative Environmental Suitability value based on the values of the environmental variables, providing a means to estimate density for areas that have not been surveyed.

2.2.3 Navy Acoustic Effects Model

NAEMO calculates sound energy propagation from sonars and other transducers (as well as air guns and explosives) during naval activities and the sound received by animat dosimeters. Animat dosimeters are virtual representations of marine mammals and/or sea turtles distributed in the area around the modeled naval activity. Each of the animat dosimeters records its individual sound "dose." The model bases the distribution of animats over the action area on the density values in the Navy Marine Species Density Database (See Section 2.2.2 above) and distributes animats in the water column proportional to the known time that species spend at varying depths.

The model accounts for environmental variability in sound propagation with both distance and depth, as well as boundary interactions, when computing the received sound level of the animats. The model conducts a statistical analysis based on multiple model runs to compute the potential acoustic effects on animals. The number of animats for which the thresholds of effects is exceeded is tallied to estimate the number of times marine mammals or sea turtles could be affected by the aspects of the proposed activity that generate sound.

Assumptions in the Navy model intentionally err on the side of overestimation when there are unknowns. Naval activities are modeled as though they would occur regardless of proximity to marine mammals or sea turtles (i.e., mitigation is not incorporated in the model) and without any avoidance of the activity by the animals.

The model estimates the impacts caused by individual training and testing events. During any individual modeled event, impacts on individual animats are considered over 24-hour periods. The animats do not represent actual animals, but rather allow for a statistical analysis of the number of instances during which marine mammals or sea turtles may be exposed to sound levels resulting in an effect. Therefore, the model estimates the number of instances for which an effects threshold may be exceeded over the course of a year, but does not estimate the number of individual marine mammals or sea turtles that may be impacted over a year (Navy 2018b). The model also does not estimate whether a single individual is exposed multiple times.

A more detailed description of NAEMO is available in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018b).

As described further in Section 3.4.2, the Navy proposes to implement a series of procedural mitigation measures designed to minimize or avoid potentially injurious impacts on marine mammals and sea turtles. The Navy implements mitigation measures when a marine mammal or sea turtle is observed in the mitigation zone. The mitigation zones encompass the estimated ranges to injury (including PTS) for sonar sources and much of the range to injury for explosives. As mentioned previously, NAEMO does not take into account mitigation measures or animal avoidance behavior when predicting impacts to marine mammals and sea turtles from acoustic stressors. Therefore, to account for the potential for mitigation measures to minimize potential impacts on marine mammals and sea turtles, the Navy quantified the potential for mitigation to reduce model-estimated PTS to TTS for exposures to sonar and other transducers, and to reduce model-estimated mortality due to injury from exposures to explosives. Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. In the quantitative analysis, consideration of mitigation measures means that, for activities where mitigation is feasible, some model-estimated PTS is considered mitigated to the level of TTS. The impact analysis does not analyze the potential for mitigation to reduce TTS or behavioral effects. Environmental conditions under which the training or testing activity could take place are also considered such as the sea surface conditions, weather (e.g., fog or rain), and day versus night.

The Navy estimated the ability of Navy Lookouts to observe the range to PTS for each training or testing event. The ability of Navy Lookouts to detect protected species in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as group size or surface active behavior). The behaviors and characteristics of some species may make them easier to detect. For example, based on small boat surveys between 2000 and 2012 in the Hawaiian Islands, pantropical spotted dolphins and striped dolphins were frequently observed leaping out of the water. This behavior is visible from a great distance and likely increases sighting distances and detections of these species.

The Navy did quantify the potential for animals to actively avoid potentially injurious sound sources. It is also well-documented (e.g., See Section 9.2.1.1.1.5) that marine mammals and sea turtles often avoid loud sound sources (e.g., those that could be injurious). Because marine mammals and sea turtles are assumed to initiate avoidance behavior when exposed to relatively high received levels of sound within their capacity to detect, an exposed animal could reduce its cumulative sound energy exposure from something like a sonar event with multiple pings (i.e., accumulated sound exposures) by leaving the area. This would reduce risk of both PTS and TTS, although the quantitative analysis only considers the potential to reduce instances of PTS by accounting for marine mammals or sea turtles swimming away to avoid repeated high-level sound exposures. All reductions in PTS impacts from likely avoidance behaviors are instead considered TTS impacts.

A full description of this process is described in in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts on Marine Mammals and Sea Turtles* (Navy 2018b).

2.3 Criteria and Thresholds to Predict Impacts to Fishes

A description of fish hearing according to their species' groups and sensitivity to sound is provided in the Section 7, as well as specific sections related to each sound source. For many of the acoustic stressors affecting fishes in the action area during the Navy's training and testing activities, the Navy relied primarily on the recommendations in the 2014 *ANSI Guidelines* (Popper et al. 2014). Where applicable, NMFS worked with the Navy to develop or use other thresholds based upon what NMFS considers to be the most appropriate given our current understanding of the effects of anthropogenic sounds on fishes as well as the best available science on the subject. For fishes, PTS has not been documented in any of the studies researching fish hearing and potential impairment from various sound sources. This is attributed to the ability for regeneration of inner ear hair cells in fishes, which differs from other marine animals. For this reason, thresholds for fish hearing impairment only includes the sound pressure level related to the potential onset of TTS. A TTS in fishes is considered recoverable, although the rate of recovery is based upon the degree of the TTS sustained. Thus, auditory damage or impairment in fishes is considered recoverable over some duration; and auditory thresholds are based solely on the onset of TTS for fishes.

For auditory impairment (e.g., TTS) and barotrauma (e.g. physical injuries) in fishes, NMFS and the Navy apply dual metric criteria which includes both a peak pressure metric and SEL_{cum}. As with other marine animals, NMFS also applies an rms threshold for some acoustics sources to assess whether behavioral responses may be elicited during some sound exposures.

2.3.1 Impulsive Sound Source Criteria (Air Guns and Pile Driving) – Fishes

Impulsive sound sources such as those produced during impact hammer pile driving or air guns use are known to injure and kill fishes or elicit behavioral responses. For air guns, the Navy estimated impacts from sound produced by air guns using the recommendations that are consistent with the *ANSI Guidelines* (Popper et al. 2014). These dual metric criteria are utilized to estimate zones of effects related to mortality and injury from air gun exposure. NMFS and the Navy assume that a specified effect will occur when either metric (peak SPL *or* $SEL_{cum)}$ is met or exceeded.

In the 2014 *ANSI Guidelines*, air gun thresholds are derived from the thresholds developed for impact pile driving exposures (Halvorsen et al. 2012c; Halvorsen et al. 2011c; Halvorsen et al. 2012d). This use of a dual metric criteria is consistent with the current impact hammer criteria NMFS applies for fishes with swim bladders (FHWG 2008; Stadler and Woodbury 2009). The interim criteria developed by the Fisheries Hydroacoustic Working Group (FHWG) include dual metric criteria wherein the onset of physical injury would be expected if either the peak SPL exceeds 206 dB re 1 μPa, or the SEL_{cum}, exceeds 187 dB re 1 μPa^2-s for fish two grams or larger, or 183 dB 1 μPa^2-s for fish smaller than two grams. However, at the time the interim criteria were developed, very little information was available regarding fish and pile driving effects. Therefore, the criteria largely used information available from air gun and explosive exposures. As such, it is also often applied to other impulsive sound sources. In addition, the 2008 interim criteria did not specifically separate thresholds according to severity of hearing impairment such as TTS to recoverable injury to mortality, which was done in the 2014 *ANSI Guidelines*. Nor do they differentiate between fish with swim bladders and those without, despite the presence of a swim bladder affecting hearing capabilities and fish sensitivity to sound. The 2008 interim criteria based the lower SEL_{cum} thresholds (187 and 183) upon when TTS or minor injuries would be expected to occur. Therefore, the criteria establish the starting point when the whole spectrum of potential physical effects may occur for fishes, from TTS to minor, recoverable injury, up to lethal injury (i.e., either resulting in either instantaneous or delayed mortality). Because some generalized groupings of fish species can be made regarding what is currently known about fish hearing sensitivities and influence of a swim bladder, we will separate ESA-listed fishes considered in this consultation based upon those anatomical features which result in varying degrees of hearing sensitivity (Casper et al. 2012c; Hastings and C. 2009; Popper et al. 2014). Categories and descriptions of hearing sensitivities are further defined in this document (modified from Popper et al. 2014) as the following[1]:

- Fishes without a swim bladder, but with hearing limited to particle motion detection at frequencies well below 1 kHz: include giant manta ray, oceanic whitetip shark, scalloped hammerhead shark, and smalltooth sawfish.
- Fishes with a swim bladder that is not involved in hearing, lack hearing specializations and primarily detect particle motion at frequencies below 1 kHz include Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, Nassau grouper, and shortnose sturgeon.

For the Navy training and testing activities, air gun and pile driving thresholds for fishes are presented in Table 8:

Table 8. Sound exposure criteria for mortality and injury from impulsive sound sources (air guns and impact hammer 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

Notes: SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa²-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.

Criteria and thresholds to estimate TTS in fishes exposed to sound produced by air guns are pile driving are presented below in

Table 9. Exposure to sound produced from an air gun at a cumulative sound exposure level of 186 dB (re 1 μPa²-s) has resulted in TTS in fishes (Popper et al. 2005b)[2]. TTS is not known to

[1] The 2014 *ANSI Guidelines* and the Navy assessment provide distinctions between fish with and without swim bladders and fish with swim bladders involved in hearing. None of the ESA-listed fish species considered in this consultation have swim bladders involved with their hearing abilities. Thus, we simplified the distinction to fishes with or without swim bladders.
[2] This is also slightly more conservative than the 2008 interim pile driving criteria of 187 SEL_{cum}.

occur in fishes without a swim bladder, but would likely occur above 186 dB SEL_{cum} (re 1 μPa^2-s).

Table 9. Fish hearing group sound exposure criteria for TTS from impulsive sound sources (air guns and impact hammer pile driving).

Fish Hearing Group	TTS (SEL_{cum})
Fishes without a swim bladder	NC
Fishes with a swim bladder not involved in 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.

For potential behavioral responses of fishes (i.e. sub-injury) from exposure to anthropogenic sounds, there are no formal criteria yet established. This is largely due to the sheer diversity of fishes, their life histories and behaviors, as well as the inherent difficulties conducting studies related to fish behavior in the wild. NMFS applies a conservative threshold of 150 dB rms (re 1 μPa) to assess potential behavioral responses of fishes from acoustic stimuli, described below.

In a study conducted by Fewtrell (2003), fish were exposed to air guns and observed to exhibit alarm responses from sound levels of 158 to 163 dB (re 1 μPa). In addition, when the 2008 criteria were being developed, one of the technical panel experts, Dr. Mardi Hastings, recommended a "safe limit" of fish exposure, meaning where no injury would be expected to occur to fishes from sound exposure, set at 150 dB rms (re 1 μPa) based upon her research (Hastings 1990a; referenced in Sonalysts 1997). This "safe limit" was also referenced in a document investigating fish effects from underwater sounds generated from construction (Sonalysts 1997) where the authors mention two studies conducted by Dr. Hastings that noted no physical damage to fishes occurred when exposed to sound levels of 150 dB rms at frequencies between 100-2,000 Hz. In that same report, the authors noted they also observed fish behavioral responses during sound exposure of 160 dB rms, albeit at very high frequencies. More recently, Fewtrell and Mccauley (2012) exposed fishes to air gun sound between 147-151 dB SEL, and observed alarm responses in fishes as well as tightly grouped swimming or fast swimming speeds[1].

None of the current research available on fish behavioral response to sound make recommendations for a non-injury threshold. The studies mentioned here, as with most data available on behavioral responses to anthropogenic sound for fishes, have been obtained through controlled laboratory studies. In other cases, behavioral studies have been conducted in the field with caged fish. Research on fish behaviors has demonstrated that caged fish do not show normal behavioral responses which makes it difficult to extrapolate caged fish behavior to wild,

[1] A more thorough discussion of fish behavior and sound criteria is provided in the effects analyses for individual sound sources later in this document.

unconfined fishes (Hawkins et al. 2014; Popper and N. 2014). It is also important to mention, that some of the information regarding fish behavior while exposed to anthropogenic sounds has been obtained from unpublished documents such as monitoring reports, grey literature, or other non-peer reviewed documents with varying degrees of quality. Therefore, behavioral effects from anthropogenic sound exposure remains poorly understood for fishes, especially in the wild. Nonetheless, potential behavioral responses must be considered as an effect of acoustic stressors on ESA-listed fishes. For the reasons discussed, and until new data indicate otherwise, NMFS believes a 150 dB rms (re 1 μPa) threshold for behavioral responses of fishes is appropriate. This criterion is used as a guideline to establish a sound level where responses of fishes may occur and could be a concern. For ESA-listed fishes, NMFS applies this criterion when considering the life stage affected, and any adverse effects that could occur from behavioral responses such as attentional disruption, which could lead to reduced foraging success, impaired predatory avoidance, leaving protective cover, release of stress hormones affecting growth rates, poor reproductive success rates and disrupted migration.

2.3.2 Sonar – Fishes

General categories and characteristics of Navy sonar systems proposed for use during activities considered are described in Section 6.1.3 (Sonar and Other Transducers). All ESA-listed fishes have the potential to be exposed to sonar and other transducers during Navy activities included in this biological opinion. Direct injury from sonar and other transducers is considered highly unlikely because injury from sound levels produced from sonar has not been documented in fishes (Halvorsen et al. 2012e; Kane et al. 2010; Popper et al. 2014; Popper et al. 2007; Popper et al. 2013). The sound characteristics (e.g., non-impulsive) of sonar are considered to pose less risk to fishes because they have lower peak pressures and slow rise times. These non-impulsive, sound sources lack the strong shock wave such as that produced from an explosion. The most probable impacts from exposure to sonar and other transducers would be in the form of TTS and would likely occur after a long duration of exposure at low frequencies, longer than most of the sonar exposures that would occur during Navy training and testing activities. Therefore, in order to evaluate the effects of sonar use during Navy activities, NMFS and the Navy use the criteria for sonar and fishes based upon the recommendations provided in the 2014 *ANSI Guidelines*. These are provided in Table 10.

Table 10. Sound exposure criteria for TTS from sonar (Navy 2017a).

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

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.

2.3.3 Explosives – Fishes

For explosives, this consultation used the mortality criteria provided in the 2014 *ANSI Guidelines*, which also divides fish according to presence of a swim bladder and if the swim bladder is involved in hearing (described above). The 2014 *ANSI Guidelines* did not suggest numeric thresholds for injury or TTS due to explosives. Therefore, the Navy's AFTT Phase III BA (Navy 2017a) and the AFTT Draft EIS/OEIS (Navy 2017c) proposed to use the impact pile driving and air gun injury thresholds suggested by the *ANSI Guidelines* as surrogates. These criteria are used for this consultation as numeric thresholds for injury and TTS in fishes.

Because we have no way of estimating the abundance and assemblage of fishes with or without these characteristics, NMFS assumes the zone of impact would encompass the distance it would take for the sound wave to reach the criteria for the most sensitive fish species. The onset of the lowest level of injury along the injury continuum, in this case would be either greater than 203 dB peak re 1 μPa, or greater than 186 dB SEL_{cum} dB re 1 μPa^2-s as indicated provided in Table 11.

Table 11. Sound exposure criteria for mortality, injury, and TTS from explosives (Navy 2017a).

Fish Hearing Group	Onset of Mortality	Onset of Injury		TTS
	SPL_{peak}	SEL_{cum}	SPL_{peak}	(SEL_{cum})
Fishes without a swim bladder	229	> 216	> 213	NC
Fishes with a swim bladder not involved in hearing	229	203	> 207	> 186

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. TTS = Temporary Threshold Shift. NC = no criteria, > indicates that the given effect would occur above the reported threshold.

During consultation, the Navy proposed an alternative peak pressure threshold for onset of injury in fishes from explosives (i.e., 220 dB peak re 1 μPa) compared with the criteria included in the Navy's BA (Navy 2017a) and the AFTT Draft EIS/OEIS (Navy 2017c). The alternative threshold is based on a compilation of data from a variety of studies on the effects of explosives on fishes with swimbladders (Gaspin 1975; Gaspin et al. 1976; Hubbs and Rechnitzer 1952a; Settle et al. 2002; Yelverton et al. 1975b) and is described in further detail in the Navy's FEIS/OEIS. Note that while we did not use this peak pressure threshold in this consultation, the threshold we did use in this consultation is more protective of the species considered in this opinion (i.e., the threshold we used is lower). We will evaluate the use of the Navy's alternative threshold for future consultations.

3 DESCRIPTION OF THE PROPOSED ACTION

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies. "Action Area" means all areas to be affected directly or indirectly by the Federal "action" and not merely the immediate area involved in the action. 50 C.F.R. §402.02.

The Navy proposes to conduct military readiness training and testing ("testing" includes research, development, testing and evaluation) activities in the AFTT action area (Figure 8). These military readiness (training and testing) activities include the use of active sonar and explosives within existing range complexes and testing ranges, in high seas areas of the Atlantic Ocean along the eastern coast of North America, the Gulf of Mexico, in portions of the Caribbean Sea, at Navy pier side locations, within port transit channels, near civilian ports, and in bays, harbors, and inshore waterways (e.g., lower Chesapeake Bay). These military readiness activities are representative of training and testing the Navy has been conducting in the AFTT action area for decades.

The NMFS Permits Division proposes to promulgate regulations pursuant to the MMPA, as amended (16 U.S.C. 1361 et seq.) for the Navy to "take" marine mammals incidental to AFTT activities. The regulations propose to authorize the issuance of an LOA that will allow the Navy to "take" marine mammals incidental to their training and testing activities. The Permits Division's proposed regulations are available at the following website: *https://www.federalregister.gov/documents/2018/03/13/2018-04517/taking-and-importing-marine-mammals-taking-marine-mammals-incidental-to-the-us-navy-training-and*. This consultation considers the MMPA regulations for the Navy to "take" marine mammals incidental to AFTT activities, as modified during ESA consultation. The final MMPA regulations, upon publication, will be available at the following website: *https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities*. Note that this biological opinion was issued prior to the publication of the final MMPA regulations in the Federal Register. We anticipate that, upon publication, the MMPA regulations will reflect the mitigation and monitoring measures proposed by the Navy and/or agreed to during ESA consultation (a description of the mitigation measures is in Section 3.4.2 of this opinion). We also anticipate that the levels of take of ESA-listed marine mammals authorized under the final MMPA regulations and LOA will be consistent with those analyzed in this opinion. Upon publication, we will review the MMPA regulations to ensure these conditions are met. If administrative changes are needed following publication of the MMPA regulations, we will update the biological opinion to reflect these changes. If more substantive changes are needed, the reinitiation triggers described in Section 15 may apply.

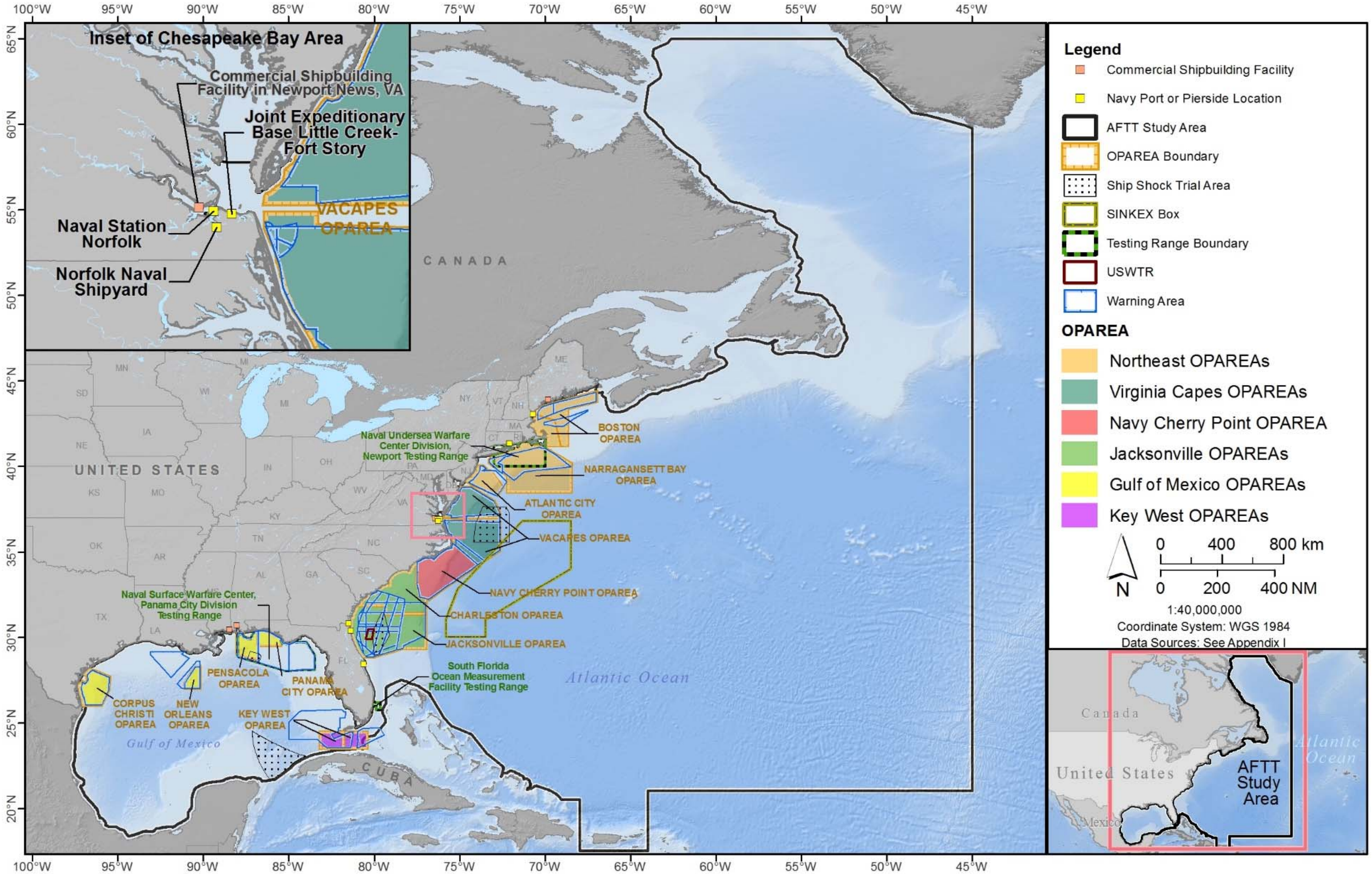


Figure 8. Atlantic Fleet Training and Testing Study Area (i.e., the action area).

For the training activities considered during consultation, Naval personnel (Sailors and Marines) first undergo entry-level (or schoolhouse) training, which varies according to their assigned warfare community (aviation, surface warfare, submarine warfare, and expeditionary warfare) and the community's unique requirements. Personnel then train within their warfare community at sea in preparation for deployment. For the testing activities considered during consultation, the Navy researches, develops, tests, and evaluates new platforms, systems, and technologies, collectively known as testing. Many tests require realistic conditions at sea and can range from testing new software to complex operations of multiple systems and platforms. Testing activities may occur independent of or in conjunction with training activities.

The sections below (Sections 3.1, 3.2, 3.3, and 3.4) provide greater detail on the Navy's proposed training and testing activities in the action area. The NMFS Permits Division proposes to promulgate regulations pursuant to the MMPA for the Navy to "take" marine mammals incidental to these activities. We present information on the locations where activities are proposed to occur, describe the specific types of activities proposed, and present information on the levels of activities proposed in the different locations. We conclude this section by presenting information on the standard operating procedures and mitigation measures that will be implemented by the Navy as part of the training and testing activities.

3.1 Location

Proposed activities will occur in the action area (Figure 8), which includes areas of the western Atlantic Ocean along the east coast of North America, portions of the Caribbean Sea, and the Gulf of Mexico. The action area begins at the mean high tide line along the U.S. coast and extends east to the 45-degree west longitude line, north to the 65-degree north latitude line, and south to approximately the 20-degree north latitude line. The action area also includes Navy pierside locations and port transit channels, bays, harbors, and inshore waterways, and civilian ports where training and testing occurs. The action area covers approximately 2.6 million square nautical miles (NM^2) of ocean area and includes designated Navy range complexes and associated OPAREAs and special use airspace. While the action area is very large, the majority of Navy training and testing activities occur in designated range complexes and testing ranges, which occupy a much smaller portion of the action area.

A Navy range complex consists of geographic areas that include a water component (above and below the surface) an airspace, and may include a land component where training and testing of military platforms, tactics, munitions, explosives, and electronic warfare systems occur.[9] Range complexes include established operating areas and special use airspace, which may be further divided to provide better control of the area for safety reasons. The terms used to describe the components of the range complexes are described below:

[9] Land components associated with the range complexes and testing ranges are not included in the action area because no activities on these land areas are included as part of the proposed action.

- **Airspace**
  - **Special Use Airspace**. Types of special use airspace most commonly found in range complexes include the following:
    - **Restricted Areas**. Airspace where aircraft are subject to restriction due to the existence of unusual, often invisible hazards (e.g., release of ordnance) to aircraft. Some areas are under strict control of the Department of Defense (DoD) and some are shared with non-military agencies.
    - **Warning Areas**. Areas of defined dimensions, extending from 3 NM outward from the coast of the United States, which serve to warn non-participating aircraft of potential danger.
    - **Air Traffic Control Assigned Airspace**. Airspace of defined vertical/lateral limits, assigned by Air Traffic Control, for the purpose of providing air traffic segregation between the specified activity being conducted within the assigned airspace and other instrument flight rules traffic.
- **Sea and Undersea Space**
  - **Operating Areas (OPAREAs)**. An ocean area defined by geographic coordinates with defined surface and subsurface areas and associated special use airspace. OPAREAs include restricted areas, which are defined water areas for the purpose of prohibiting or limiting public access to the area. Restricted areas generally provide security for government property and also provide protection to the public from the risks of damage or injury arising from the government's use of that area.

The range complexes and testing ranges are described in the following sections. The action area also includes various bays, harbors, inshore waterways, and pierside locations, which are within the boundaries of the range complexes. These areas are described in Section 3.1.10.

3.1.1 Northeast Range Complexes

The Northeast Range Complexes include the Boston Range Complex, Narragansett Bay Range Complex, and Atlantic City Range Complex (Figure 9). These range complexes span 761 miles along the coast from Maine to New Jersey. The Northeast Range Complexes include special use airspace with associated warning areas and surface and subsurface sea space of the Boston OPAREA, Narragansett Bay OPAREA, and Atlantic City OPAREA.

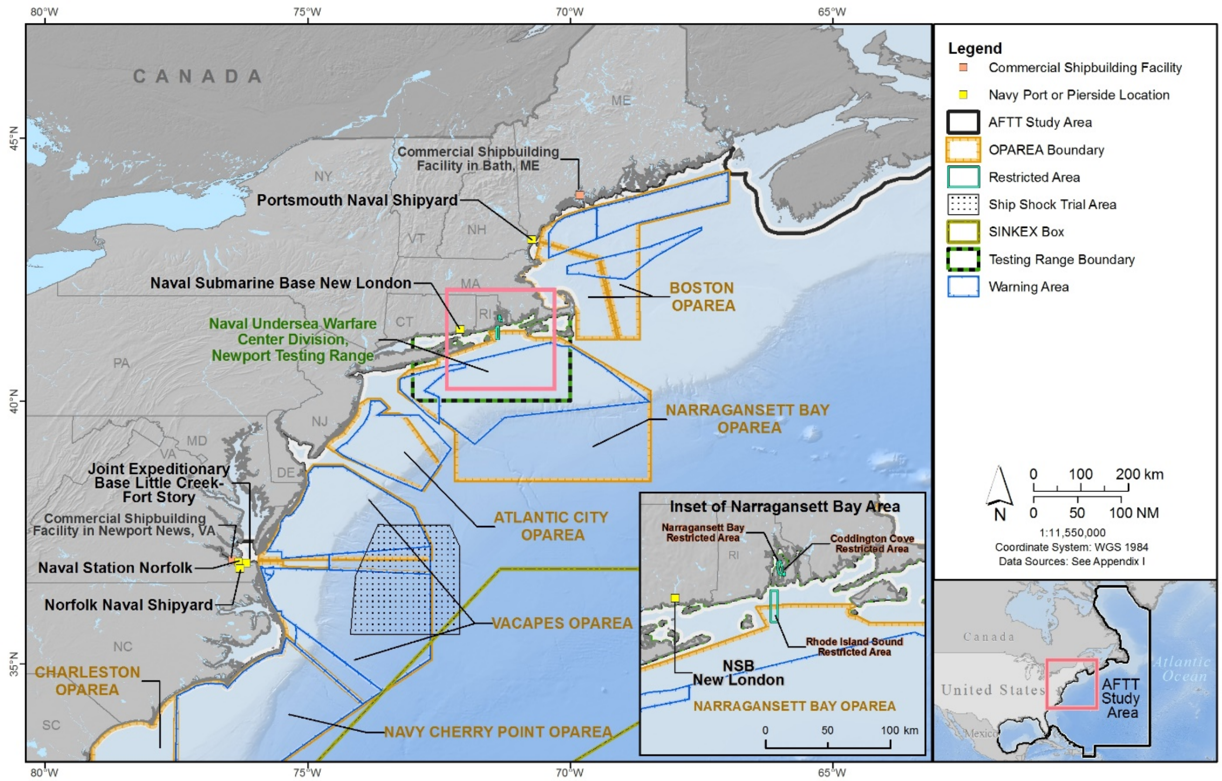


Figure 9. Northeast and Mid-Atlantic region of the action area.

Airspace – The Northeast Range Complexes include over 25,000 NM^2 of special use airspace. The altitude at which aircraft may fly varies from just above the surface to 60,000 feet (ft), except for one specific warning area (W-107A) in the Atlantic City Range Complex, which is from 18,000 ft to unlimited altitudes. Six warning areas are located within the Northeast Range Complexes.

Sea and Undersea Space – The Northeast Range Complexes include three OPAREAs—Boston, Narragansett Bay, and Atlantic City. These OPAREAs encompass over 45,000 NM^2 of sea space and undersea space. The Boston, Narragansett Bay, and Atlantic City OPAREAs are offshore of the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, and New Jersey. The OPAREAs of the three complexes are outside 3 NM but within 200 NM from shore.

3.1.2 Naval Undersea Warfare Center Division, Newport Testing Range

The Naval Undersea Warfare Center Division, Newport Testing Range includes the waters of Narragansett Bay, Rhode Island Sound, Block Island Sound, Buzzards Bay, Vineyard Sound, and Long Island Sound (Figure 9).

Airspace – A portion of Naval Undersea Warfare Center Division, Newport Testing Range is under restricted area R-4105A, known as No Man's Land Island. A minimal amount of testing occurs in the airspace within Naval Undersea Warfare Center Division, Newport Testing Range.

Sea and Undersea Space – Three restricted areas are located within the area of the Naval Undersea Warfare Center Division, Newport Testing Range:

- Coddington Cove restricted area, adjacent to Naval Undersea Warfare Center Division, Newport
- Narragansett Bay Restricted Area (6.1 NM^2 area surrounding Gould Island) including the Hole Test Area and the North Test Range
- Rhode Island Sound Restricted Area, a rectangular box (27.2 NM^2) located in Rhode Island and Block Island Sounds

3.1.3 Virginia Capes Range Complex

The Virginia Capes Range Complex spans 270 miles along the coast from Delaware to North Carolina from the shoreline to 155 NM seaward (Figure 9). The Virginia Capes Range Complex includes special use airspace with associated warning and restricted areas, and surface and subsurface sea space of the Virginia Capes OPAREA. The Virginia Capes Range Complex also includes established mine warfare training areas located within the lower Chesapeake Bay and off the coast of Virginia.

Airspace – The Virginia Capes Range Complex includes over 28,000 NM^2 of special use airspace. Flight altitudes range from surface to unlimited altitudes. Five warning areas are located within the Virginia Capes Range Complex. Restricted airspace extends from the shoreline to approximately the 3 NM state territorial sea limit within the Virginia Capes Range Complex and is designated as R-6606.

Sea and Undersea Space – The Virginia Capes Range Complex shore boundary roughly follows the shoreline from Delaware to North Carolina; the seaward boundary extends 155 NM into the Atlantic Ocean proximate to Norfolk, Virginia. The Virginia Capes OPAREA encompasses over 27,000 NM^2 of sea space and undersea space. The Virginia Capes OPAREA is offshore of the states of Delaware, Maryland, Virginia, and North Carolina.

3.1.4 Navy Cherry Point Range Complex

The Navy Cherry Point Range Complex, off the coast of North Carolina and South Carolina, encompasses the sea space from the shoreline to 120 NM seaward. The Navy Cherry Point Range Complex includes special use airspace with associated warning areas and surface and subsurface sea space of the Cherry Point OPAREA (Figure 7). The Navy Cherry Point Range Complex is adjacent to the U.S. Marine Corps Cherry Point and Camp Lejeune Range

Complexes associated with Marine Corps Air Station Cherry Point and Marine Corps Base Camp Lejeune.

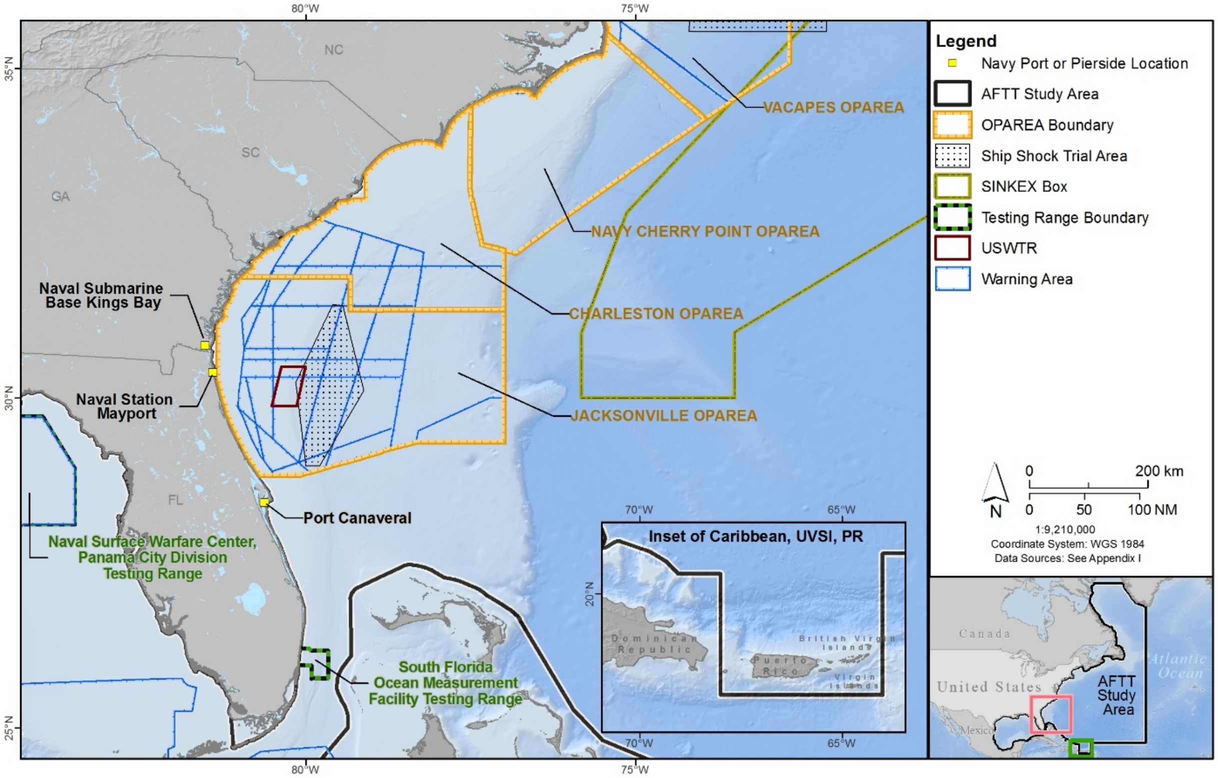


Figure 7. Southeast region of the action area.

Airspace – The Navy Cherry Point Range Complex includes over 18,000 NM^2 of special use airspace. The airspace varies from the surface to unlimited altitudes. A single warning area is located within the Navy Cherry Point Range Complex.

Sea and Undersea Space – The Navy Cherry Point Range Complex is roughly aligned with the shoreline and extends out 120 NM into the Atlantic Ocean. The Navy Cherry Point OPAREA encompasses over 18,000 NM^2 of sea space and undersea space.

3.1.5 Jacksonville Range Complex

The Jacksonville Range Complex spans 520 miles along the coast from North Carolina to Florida from the shoreline to 250 NM seaward. The Jacksonville Range Complex includes special use airspace with associated warning areas and surface and subsurface sea space of the Charleston and Jacksonville OPAREAs. The Undersea Warfare Training Range (USWTR) is located within the Jacksonville Range Complex (Figure 7).

Airspace – The Jacksonville Range Complex includes approximately 40,000 NM^2 of special use airspace. Flight altitudes range from the surface to unlimited altitudes. Nine warning areas are located within the Jacksonville Range Complex.

Sea and Undersea Space – The Jacksonville Range Complex shore boundary roughly follows the shoreline and extends out 250 NM into the Atlantic Ocean proximate to Jacksonville, Florida. The Jacksonville Range Complex includes two OPAREAs: Charleston and Jacksonville. Combined, these OPAREAs encompass over 50,000 NM^2 of sea space and undersea space. The Charleston and Jacksonville OPAREAs are offshore of the states of North Carolina, South Carolina, Georgia, and Florida. The Undersea Warfare Training Range is located within the Jacksonville Range Complex.

3.1.6 Naval Surface Warfare Center Carderock Division, South Florida Ocean Measurement Facility Testing Range

The Naval Surface Warfare Center Carderock Division operates the South Florida Ocean Measurement Facility Testing Range (SFOMF), an offshore testing area in support of various Navy and non-Navy programs. The SFOMF is located adjacent to the Port Everglades entrance channel in Fort Lauderdale, Florida (Figure 7). The test area at the SFOMF includes an extensive cable field located within a restricted anchorage area and two designated submarine OPAREAs.

Airspace – The SFOMF does not have associated special use airspace. The airspace adjacent to the SFOMF is managed by the Fort Lauderdale International Airport. Air operations at the SFOMF are coordinated with Fort Lauderdale International Airport by the air units involved in the testing events.

Sea and Undersea Space – The SFOMF is divided into four subareas:

- The Port Everglades Shallow Submarine OPAREA is a 120-NM^2 area that encompasses nearshore waters from the shoreline to 900 ft deep and 8 NM offshore.
- The Training Minefield is a 41-NM^2 area used for special purpose surface ship and submarine operations where the test vessels are restricted from maneuvering and require additional protection. This Training Minefield encompasses waters from 60 to 600 ft deep and from 1 to 3 NM offshore.
- The Port Everglades Deep Submarine OPAREA is a 335-NM^2 area that encompasses the offshore range from 900 to 2,500 ft in depth and from 9 to 25 NM offshore.
- The Port Everglades Restricted Anchorage Area is an 11-NM^2 restricted anchorage area ranging in depths from 60 to 600 ft where the majority of the SFOMF cables run from offshore sensors to the shore facility and where several permanent measurement arrays are used for vessel signature acquisition.

3.1.7 Key West Range Complex

The Key West Range Complex (KWRC) lies off the southwestern coast of mainshore Florida and along the southern Florida Keys, extending seaward into the Gulf of Mexico 150 NM and south into the Straits of Florida 60 NM. The KWRC includes special use airspace with associated warning areas and surface and subsurface sea space of the Key West OPAREA (Figure 10).

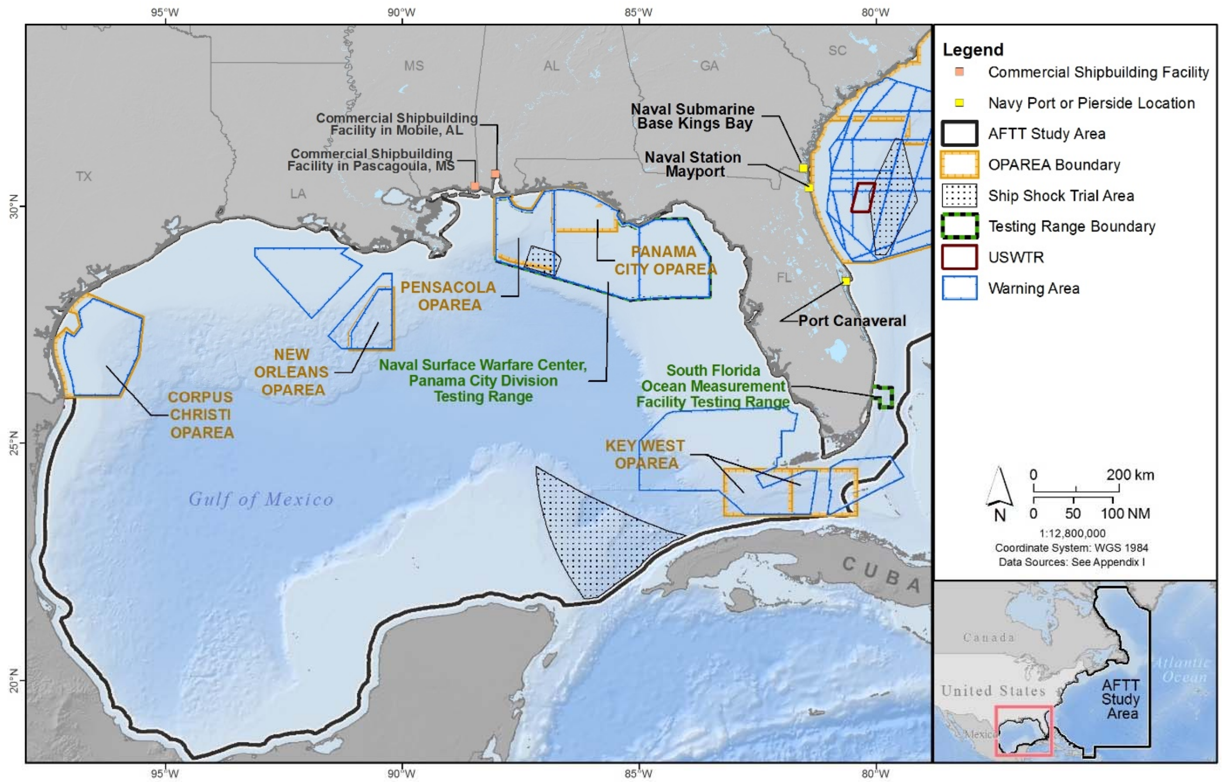


Figure 10. Gulf of Mexico region of the action area.

Airspace – The KWRC includes over 20,000 NM^2 of special use airspace. Flight altitudes range from the surface to unlimited altitudes. Eight warning areas, Bonefish Air Traffic Control Assigned Airspace, and Tortugas Military OPAREA are located within the KWRC.

Sea and Undersea Space – The Key West OPAREA is over 8,000 NM^2 of sea space and undersea space south of Key West, Florida.

3.1.8 Naval Surface Warfare Center, Panama City Division Testing Range

The Naval Surface Warfare Center, Panama City Division Testing Range is located off the panhandle of Florida and Alabama, extending from the shoreline to 120 NM seaward, and includes St. Andrew Bay. Naval Surface Warfare Center, Panama City Division Testing Range also includes special use airspace and offshore surface and subsurface waters of offshore OPAREAs (Figure 10).

Airspace – Special use airspace associated with Naval Surface Warfare Center, Panama City Division Testing Range includes three warning areas.

Sea and Undersea Space – The Naval Surface Warfare Center, Panama City Division Testing Range includes the waters of St. Andrew Bay and the sea space within the Gulf of Mexico from the mean high tide line to 120 NM offshore. The Panama City OPAREA covers just over 3,000 NM^2 of sea space and lies off the coast of the Florida panhandle. The Pensacola OPAREA lies off the coast of Alabama and Florida west of the Panama City OPAREA and totals just under 5,000 NM^2.

3.1.9 Gulf of Mexico Range Complex

Unlike most of the range complexes previously described, the Gulf of Mexico Range Complex includes geographically separated areas throughout the Gulf of Mexico. The Gulf of Mexico Range Complex includes special use airspace with associated warning areas and restricted airspace and surface and subsurface sea space of the Panama City, Pensacola, New Orleans, and Corpus Christi OPAREAs (Figure 10).

Airspace – The Gulf of Mexico Range Complex includes approximately 20,000 NM^2 of special use airspace. Flight altitudes range from the surface to unlimited altitudes. Six warning areas are located within the Gulf of Mexico Range Complex. Restricted airspace associated with the Pensacola OPAREA, designated R-2908, extends from the shoreline to approximately 3 NM offshore.

Sea and Undersea Space – The Gulf of Mexico Range Complex encompasses approximately 17,000 NM^2 of sea and undersea space and includes 285 NM of coastline. The OPAREAs span from the eastern shores of Texas to the western panhandle of Florida. They are described as follows:

- Panama City OPAREA lies off the coast of the Florida panhandle and totals approximately 3,000 NM^2.
- Pensacola OPAREA lies off the coast of Florida west of the Panama City OPAREA and totals approximately 4,900 NM^2.
- New Orleans OPAREA lies off the coast of Louisiana and totals approximately 2,600 NM^2.
- Corpus Christi OPAREA lies off the coast of Texas and totals approximately 6,900 NM^2.

3.1.10 Inshore Locations

Although included within the boundaries of the range complexes described above, various inshore locations, including piers, bays, and civilian ports, are identified below as some activities are proposed to occur only at these inshore locations (Figure 9).

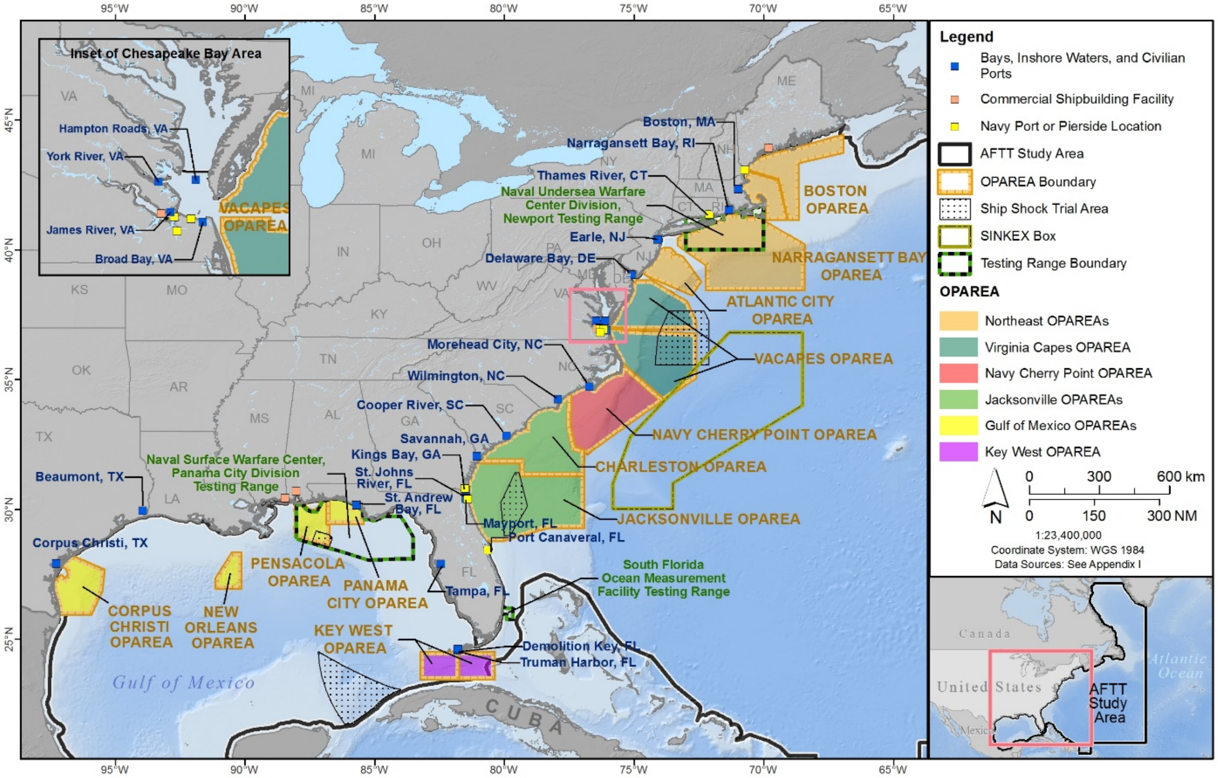


Figure 9. Inshore locations within the action area.

3.1.10.1 Pierside Locations

Pierside locations include channels and transit routes in ports and facilities associated with the following Navy ports and naval shipyards:

- Portsmouth Naval Shipyard, Kittery, Maine
- Naval Submarine Base New London, Groton, Connecticut
- Naval Station Norfolk, Norfolk, Virginia
- Joint Expeditionary Base Little Creek-Fort Story, Virginia Beach, Virginia
- Norfolk Naval Shipyard, Portsmouth, Virginia
- Naval Submarine Base Kings Bay, Kings Bay, Georgia
- Naval Station Mayport, Jacksonville, Florida
- Port Canaveral, Cape Canaveral, Florida

Navy contractor shipyards in the following cities are also in the action area:

- Bath, Maine
- Groton, Connecticut
- Newport News, Virginia
- Mobile, Alabama
- Pascagoula, Mississippi

3.1.10.2 Bays, Harbors, and Inshore Waterways

Inshore waterways used for training and testing activities include the following:

- Narragansett Bay Range Complex/Naval Undersea Warfare Center Division, Newport Testing Range: Thames River, Narragansett Bay
- Virginia Capes Range Complex: Lower Chesapeake Bay, James River and tributaries, York River, Broad Bay
- Jacksonville Range Complex: southeast Kings Bay, Cooper River, St. Johns River
- KWRC: Truman Harbor, Demolition Key
- Gulf of Mexico Range Complex/Naval Surface Warfare Center, Panama City Division: St. Andrew Bay

3.1.10.3 Civilian Ports

Civilian ports identified for civilian port defense training events include the following:

- Boston, Massachusetts
- Earle, New Jersey
- Delaware Bay, Delaware
- Hampton Roads, Virginia
- Morehead City, North Carolina
- Wilmington, North Carolina
- Kings Bay, Georgia
- Mayport, Florida
- Port Canaveral, Florida
- Tampa, Florida
- Beaumont, Texas
- Corpus Christi, Texas
- Savannah, Georgia

3.2 Primary Mission Areas

The Navy categorizes its activities into functional warfare areas called primary mission areas. These activities generally fall into the following seven primary mission areas:

- air warfare
- amphibious warfare
- anti-submarine warfare
- electronic warfare
- expeditionary warfare
- mine warfare
- surface warfare

Most activities proposed by the Navy are categorized into one of these primary mission areas, though the testing community has three additional categories of activities for vessel evaluation, unmanned systems, and acoustic and oceanographic science and technology. Activities that do not fall within these areas are listed as “other activities” below. Each warfare community (surface, subsurface, aviation, and expeditionary warfare) may train in some or all of these primary mission areas. The research and acquisition community also categorizes most, but not all, of its testing activities under these primary mission areas.

A detailed description of the sonar, munitions, targets, systems and other material used during training and testing activities within these primary mission areas is provided in Appendix A (Navy Activity Descriptions) of the AFTT DEIS/Overseas EIS (OEIS; Navy 2017c).

3.2.1 Air Warfare

The mission of air warfare is to destroy or reduce enemy air and missile threats (including unmanned airborne threats). Aircraft conduct air warfare through radar search, detection, identification, and engagement of airborne threats. Surface ships conduct air warfare through an array of modern anti-aircraft weapon systems such as aircraft detecting radar, naval guns linked to radar-directed fire-control systems, surface-to-air missile systems, and radar-controlled cannons for close-in point defense.

Testing of air warfare systems is required to ensure the equipment is fully functional under the conditions in which it will be used. Tests may be conducted on radar and other early warning detection and tracking systems, new guns or gun rounds, and missiles. Testing of these systems may be conducted on new ships and aircraft, and on existing ships and aircraft following maintenance, repair, or modification. For some systems, tests are conducted periodically to assess operability. Additionally, tests may be conducted in support of scientific research to assess new and emerging technologies.

3.2.2 Amphibious Warfare

The mission of amphibious warfare is to project military power from the sea to the shore (i.e., attack a threat on land by a military force embarked on ships) through the use of naval firepower and expeditionary landing forces. Amphibious warfare operations include small unit reconnaissance or raid missions to large-scale amphibious exercises involving multiple ships and aircraft combined into a strike group.

Amphibious warfare training ranges from individual, crew, and small unit events to large task force exercises. Individual and crew training include amphibious vehicles and naval gunfire support training. Such training includes shore assaults, boat raids, airfield or port seizures, and reconnaissance. Large-scale amphibious exercises involve ship-to-shore maneuver, naval fire support, such as shore bombardment, air strikes, and attacks on targets that are in close proximity to friendly forces.

Testing of guns, munitions, aircraft, ships, and amphibious vessels and vehicles used in amphibious warfare are often integrated into training activities and, in most cases, the systems are used in the same manner in which they are used for fleet training activities. Amphibious warfare tests, when integrated with training activities or conducted separately as full operational evaluations on existing amphibious vessels and vehicles following maintenance, repair, or modernization, may be conducted independently or in conjunction with other amphibious ship and aircraft activities. Testing is performed to ensure effective ship-to-shore coordination and transport of personnel, equipment, and supplies. Tests may also be conducted periodically on other systems, vessels, and aircraft intended for amphibious operations to assess operability and to investigate efficacy of new technologies.

3.2.3 Anti-Submarine Warfare

The mission of anti-submarine warfare is to locate, neutralize, and defeat hostile submarine forces that threaten Navy forces. Anti-submarine warfare is based on the principle that surveillance and attack aircraft, ships, and submarines all search for hostile submarines. These forces operate together or independently to gain early warning and detection and to localize, track, target, and attack submarine threats.

Anti-submarine warfare training addresses basic skills such as detecting and classifying submarines, as well as evaluating sounds to distinguish between enemy submarines and friendly submarines, ships, and marine life. More advanced training integrates the full spectrum of anti-submarine warfare from detecting and tracking a submarine to attacking a target using either exercise torpedoes (i.e., torpedoes that do not contain a warhead) or simulated weapons. These integrated anti-submarine warfare training exercises are conducted in coordinated, at-sea training events involving submarines, ships, and aircraft.

Testing of anti-submarine warfare systems is conducted to develop new technologies and assess weapon performance and operability with new systems and platforms, such as unmanned systems. Testing uses ships, submarines, and aircraft to demonstrate capabilities of torpedoes, missiles, countermeasure systems, and underwater surveillance and communications systems. Tests may be conducted as part of a large-scale fleet training event involving submarines, ships, fixed-wing aircraft, and helicopters. These integrated training events offer opportunities to conduct research and acquisition activities and to train aircrew in the use of new or newly enhanced systems during a large-scale, complex exercise.

3.2.4 Electronic Warfare

The mission of electronic warfare is to degrade the enemy’s ability to use electronic systems, such as communication systems and radar, and to confuse or deny them the ability to defend their forces and assets. Electronic warfare is also used to detect enemy threats and counter their attempts to degrade the electronic capabilities of the Navy.

Typical electronic warfare training activities include threat avoidance, signals analysis for intelligence purposes, and use of airborne and surface electronic jamming devices to defeat tracking and communications systems.

Testing of electronic warfare systems is conducted to improve the capabilities of systems and ensure compatibility with new systems. Testing involves the use of aircraft, surface ships, and submarine crews to evaluate the effectiveness of electronic systems. Similar to training activities, typical electronic warfare testing activities include the use of airborne and surface electronic jamming devices, including testing chaff and flares, to defeat tracking and communications systems. Chaff tests evaluate newly developed or enhanced chaff, chaff dispensing equipment, or modified aircraft systems' use against chaff deployment. Flare tests evaluate deployment performance and crew competency with newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems' use against flare deployment.

3.2.5 Expeditionary Warfare

The mission of expeditionary warfare is to provide security and surveillance in the littoral (at the shoreline), riparian (along a river), and coastal environments. Expeditionary warfare is wide ranging and includes defense of harbors, operation of remotely operated vehicles, defense against swimmers, and boarding/seizure operations.

Expeditionary warfare training activities include underwater construction team training, dive and salvage operations, and insertion/extraction via air, surface, and subsurface platforms.

3.2.6 Mine Warfare

The mission of mine warfare is to detect, classify, and avoid or neutralize (disable) mines to protect Navy ships and submarines and to maintain free access to ports and shipping lanes. Mine warfare also includes offensive mine laying to gain control of or deny the enemy access to sea space. Naval mines can be laid by ships, submarines, or aircraft.

Mine warfare neutralization training includes exercises in which ships, aircraft, submarines, underwater vehicles, unmanned vehicles, or marine mammal detection systems search for mine shapes. Personnel train to destroy or disable mines by attaching underwater explosives to or near the mine or using remotely operated vehicles to destroy the mine.

Testing and development of mine warfare systems is conducted to improve sonar, laser, and magnetic detectors intended to hunt, locate, and record the positions of mines for avoidance or subsequent neutralization. Mine warfare testing and development falls into two primary categories: mine detection and classification, and mine countermeasure and neutralization. Mine detection and classification testing involve the use of air, surface, and subsurface vessels and uses sonar, including towed and side-scan sonar, and unmanned vehicles to locate and identify objects underwater. Mine detection and classification systems are sometimes used in conjunction with a mine neutralization system. Mine countermeasure and neutralization testing include the use of air, surface, and subsurface units to evaluate the effectiveness of tracking devices, countermeasure and neutralization systems, and general purpose bombs to neutralize mine threats. Most neutralization tests use mine shapes, or non-explosive practice mines, to evaluate a new or enhanced capability. For example, during a mine neutralization test, a previously located mine is destroyed or rendered nonfunctional using a helicopter or manned/unmanned surface vehicle based system that may involve the deployment of a towed neutralization system.

A small percentage of mine warfare tests require the use of high-explosive mines to evaluate and confirm the ability of the system to neutralize a high-explosive mine under operational conditions. The majority of mine warfare systems are deployed by ships, helicopters, and unmanned vehicles. Tests may also be conducted in support of scientific research to support these new technologies.

3.2.7 Surface Warfare

The mission of surface warfare is to obtain control of sea space from which naval forces may operate and entails offensive action against other surface, subsurface, and air targets while also defending against enemy forces. In surface warfare, aircraft use cannons, air-launched cruise missiles, or other precision-guided munitions; ships employ torpedoes, naval guns, and surface-to-surface missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles.

Surface warfare training includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and submarine missile or torpedo launch events, and other munitions against surface targets.

Testing of weapons used in surface warfare is conducted to develop new technologies and to assess weapon performance and operability with new systems and platforms, such as unmanned systems. Tests include various air-to-surface guns and missiles, surface-to-surface guns and missiles, and bombing tests. Testing events may be integrated into training activities to test aircraft or aircraft systems in the delivery of ordnance on a surface target. In most cases the tested systems are used in the same manner in which they are used for fleet training activities.

3.3 Proposed Training and Testing Activities

The Navy proposes to conduct military readiness training and testing activities into the reasonably foreseeable future, as necessary to meet current and future readiness requirements. The Navy has been conducting military readiness activities in the action area for well over a century and with active sonar for over 70 years. The tempo and types of training and testing activities have fluctuated because of the introduction of new technologies, the evolving nature of international events, advances in warfighting doctrine and procedures, and changes in force structure (organization of ships, weapons, and personnel). Such developments influence the frequency, duration, intensity, and location of required training and testing activities. The types and numbers of activities proposed by the Navy reflect the most up-to-date compilation of training and testing activities deemed necessary to accomplish military readiness requirements and account for fluctuations in training and testing in order to meet evolving or emergent military readiness requirements. The proposed training and testing activities are detailed in the following sections. For the purposes of this consultation and for the proposed MMPA rule, the Navy identified the number and duration of training and testing activities that could occur over every 5-year period, beginning in November 2018.

NMFS recognizes that while Navy training and testing requirements change over time in response to global or geopolitical events and other factors, the general types of activities addressed by this consultation are expected to continue into the reasonably foreseeable future, along with the associated impacts. Therefore, as part of our effects analysis, we assumed that the training and testing activities proposed by the Navy during the period of NMFS' proposed incidental take authorization pursuant to the MMPA would continue into the reasonably foreseeable future at levels similar to those assessed in this opinion.

3.3.1 Training Activities

Training exercises vary in scale and duration. A major training exercise comprises several "unit level" type exercises conducted by several units operating together while commanded and controlled by a single commander. In a major training exercise, most of the operations and activities being directed and coordinated by the strike group commander are identical in nature to the operations conducted during individual, crew, and smaller unit level training events. In a major training exercise, however, these disparate training tasks are conducted in concert, rather than in isolation. Some integrated or coordinated anti-submarine warfare exercises[10] are similar in that they are composed of several unit level exercises but are generally on a smaller scale than a major training exercise, are shorter in duration, use fewer assets, and use fewer hours of hull-mounted sonar per exercise.

Three key factors are used by the Navy to identify and group exercises: 1) the scale of the exercise, 2) duration of the exercise, and 3) amount of hull-mounted sonar hours modeled/used for the exercise. Table 12 provides information regarding the differences between major anti-submarine warfare training events and smaller integrated/ coordinated anti-submarine exercises based on scale, duration, and sonar hours. As indicated above, unit level or smaller exercises are also proposed in the action area.

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[10] Coordinated training exercises involve multiple units working together to meet unit-level training requirements, whereas integrated training exercises involve multiple units working together to certify for deployment.

Table 12. Major anti-submarine warfare training exercises and integrated/coordinated training (Navy 2017a).

	Exercise Group	Description	Scale	Duration	Location	Exercise Examples	Modeled Hull-Mounted Sonar per Exercise
Major Training Exercise	Large Integrated ASW	Larger-scale, longer duration integrated ASW exercises	Greater than 6 surface ASW units (up to 30 with the largest exercises), 2 or more submarines, multiple ASW aircraft	Generally greater than 10 days	Jacksonville RC Navy Cherry Point RC Virginia Capes RC	COMPTUEX	>500 hours
	Medium Integrated ASW	Medium-scale, medium duration integrated ASW exercises	Approximately 3–8 surface ASW units, at least 1 submarine, multiple ASW aircraft	Generally 4–10 days	Jacksonville RC Navy Cherry Point RC Virginia Capes RC	FLEETEX/ SUSTEX	100–500 hours
Integrated/Coordinated Training	Small Integrated ASW	Small-scale, short duration integrated ASW exercises	Approximately 3–6 surface ASW units, 2 dedicated submarines, 2–6 ASW aircraft	Generally less than 5 days	Jacksonville RC Navy Cherry Point RC Virginia Capes RC	SWATT, NUWTAC	50–100 hours
	Medium Coordinated ASW	Medium-scale, medium duration, coordinated ASW exercises	Approximately 2–4 surface ASW units, possibly a submarine, 2–5 ASW aircraft	Generally 3-10 days	Jacksonville RC Navy Cherry Point RC Virginia Capes RC	TACDEVEX	Less than 100 hours
	Small Coordinated ASW	Small-scale, short duration coordinated ASW exercises	Approximately 2–4 surface ASW units, possibly a submarine, 1–2 ASW aircraft	Generally 2–4 days	Jacksonville RC Navy Cherry Point RC Virginia Capes RC	ARG/MEU, Group Sail	Less than 50 hours

Notes: ASW: anti-submarine warfare; Jacksonville: Jacksonville; RC: Range Complex; Virginia Capes: Virginia Capes; COMTUEX: Composite Training Unit Exercise; FLEETEX/SUSTEX: Fleet Exercise/Sustainment Exercise; SWATT: Surface Warfare Advanced Tactical Training Exercise; NUWTAC: Navy Undersea Warfare Training Assessment Course; TACDEVEX: Tactical Development Exercise; ARG/MEU: Amphibious Ready Group/Marine Expeditionary Unit

The training activities proposed by the Navy are described in Table 11, which include the activity name and a short description of the activity. Appendix A (Navy Activity Descriptions) of the AFTT Draft EIS/OEIS (Navy 2017c) has more detailed descriptions of the activities.

Table 11. A description of each of the proposed training activities (Navy 2017a).

Activity Name	Activity Description
Major Training Exercises – Large Integrated Anti-Submarine Warfare	
Composite Training Unit Exercise	Aircraft carrier and its associated aircraft integrate with surface and submarine units in a challenging multi-threat operational environment in order to certify them for deployment. Only the anti-submarine warfare portion of a Composite Training Unit Exercises is included in this activity; other training objectives are met via unit level training described in each of the primary mission areas below.
Major Training Exercises – Medium Integrated Anti-Submarine Warfare	
Fleet Exercises/Sustainment Exercise	Aircraft carrier and its associated aircraft integrate with surface and submarine units in a challenging multi-threat operational environment in order to maintain their ability to deploy. Fleet Exercises and Sustainment Exercises are similar to Composite Training Unit Exercises, but are shorter in duration.
Integrated/Coordinated Training – Small Integrated Anti-Submarine Warfare Training	
Naval Undersea Warfare Training Assessment Course	Multiple ships, aircraft, and submarines integrate the use of their sensors to search for, detect, classify, localize, and track a threat submarine in order to launch an exercise torpedo.
Surface Warfare Advanced Tactical Training	Multiple ships and aircraft use sensors, including sonobuoys, to search, detect, and track a threat submarine. Surface Warfare Advanced Tactical Training exercises are not dedicated anti-submarine warfare events and involve multiple warfare areas.
Integrated/Coordinated Training – Medium Coordinated Anti-Submarine Warfare Training	
Anti-Submarine Warfare Tactical Development Exercise	Surface ships, aircraft, and submarines coordinate to search for, detect, and track submarines.
Integrated/Coordinated Training – Small Coordinated Anti-Submarine Warfare Training	
Amphibious Ready Group/Marine Expeditionary Unit Exercise	Navy and Marine Corps forces conduct advanced training at sea in preparation for deployment.
Group Sail	Surface ships and helicopters search for, detect, and track threat submarines. Group Sails are not dedicated anti-submarine warfare events and involve multiple warfare areas; non-anti-submarine warfare training objectives are met via unit level training described in the primary mission areas below.
Air Warfare	
Air Combat Maneuver	Fixed-wing aircrews aggressively maneuver against threat aircraft to gain tactical advantage.
Air Defense Exercises	Aircrews and ship crews conduct defensive measures against threat aircraft or simulated missiles.
Gunnery Exercise Air-to-Air Medium-Caliber	Fixed-wing aircraft fire medium-caliber guns at air targets.
Gunnery Exercise Surface-to-Air Large-Caliber	Surface ship crews fire large-caliber guns at air targets.
Gunnery Exercise Surface-to-Air Medium-Caliber	Surface ship crews fire medium-caliber guns at air targets.
Missile Exercise Air-to-Air	Fixed-wing and helicopter aircrews fire air-to-air missiles at air targets.
Missile Exercise Surface-to-Air	Surface ship crews fire surface-to-air missiles at air targets.
Missile Exercise	Personnel employ shoulder-fired surface-to-air missiles at air targets.

Activity Name	Activity Description
Man-Portable Air Defense System	
Amphibious Warfare	
Amphibious Marine Expeditionary Unit Integration Exercise	Navy and Marine Corps forces conduct integration training at sea in preparation for deployment certification.
Amphibious Assault	Large unit forces move ashore from amphibious ships at sea for the immediate execution of inshore objectives.
Amphibious Raid	Small unit forces move from amphibious ships at sea to shore locations for a specific short-term mission. These are quick operations with as few personnel as possible.
Amphibious Vehicle Maneuvers	Personnel operate amphibious vehicles for driver training.
Humanitarian Assistance Operations	Navy and Marine Corps forces evacuate noncombatants from hostile or unsafe areas or provide humanitarian assistance in times of disaster.
Marine Expeditionary Unit Certification Exercise	Amphibious Ready Group exercises are conducted to validate the Marine Expeditionary Unit's readiness for deployment and includes small boat raids; visit, board, search, and seizure training; helicopter and mechanized amphibious raids; and a non-combatant evacuation operations.
Naval Surface Fire Support Exercise – At Sea	Surface ship crews use large-caliber guns to support forces ashore; however, the land target is simulated at sea. Rounds are scored by passive acoustic buoys located at or near the target area.
Naval Surface Fire Support Exercise – Land-Based Target	Surface ship crews fire large-caliber guns at land-based targets to support forces ashore.
Anti-Submarine Warfare	
Anti-Submarine Warfare Torpedo Exercise – Helicopter	Helicopter aircrews search for, track, and detect submarines. Recoverable air launched torpedoes are employed against submarine targets.
Anti-Submarine Warfare Torpedo Exercise – Maritime Patrol Aircraft	Maritime patrol aircraft aircrews search for, track, and detect submarines. Recoverable air launched torpedoes are employed against submarine targets.
Anti-Submarine Warfare Torpedo Exercise – Ship	Surface ship crews search for, track, and detect submarines. Exercise torpedoes are used.
Anti-Submarine Warfare Torpedo Exercise – Submarine	Submarine crews search for, track, and detect submarines. Exercise torpedoes are used.
Anti-Submarine Warfare Tracking Exercise – Helicopter	Helicopter aircrews search for, track, and detect submarines.
Anti-Submarine Warfare Tracking Exercise – Maritime Patrol Aircraft	Maritime patrol aircraft aircrews search for, track, and detect submarines.
Anti-Submarine Warfare Tracking Exercise – Ship	Surface ship crews search for, track, and detect submarines.
Anti-Submarine Warfare Tracking Exercise – Submarine	Submarine crews search for, track, and detect submarines.
Electronic Warfare	
Counter Targeting Chaff Exercise – Aircraft	Fixed-winged aircraft and helicopter aircrews deploy chaff to disrupt threat targeting and missile guidance radars.
Counter Targeting Chaff Exercise – Ship	Surface ship crews deploy chaff to disrupt threat targeting and missile guidance radars.
Counter Targeting Flare Exercise	Fixed-winged aircraft and helicopter aircrews deploy flares to disrupt threat infrared missile guidance systems.

Activity Name	Activity Description
Electronic Warfare Operations	Aircraft and surface ship crews control the electromagnetic spectrum used by enemy systems to degrade or deny the enemy's ability to take defensive actions.
High-Speed Anti-Radiation Missile Exercise	Aircrews launch a High-Speed Anti-Radiation Missile against threat radar sites.
Expeditionary Warfare	
Dive and Salvage Operations	Navy divers perform dive operations and salvage training.
Maritime Security Operations – Anti-Swimmer Grenades	Small boat crews engage in force protection activities by using anti-swimmer grenades to defend against hostile divers.
Personnel Insertion/Extraction – Air	Personnel are inserted into and extracted from an objective area by airborne platforms.
Personnel Insertion/Extraction – Surface and Subsurface	Personnel are inserted into and extracted from an objective area by small boats or subsurface platforms.
Personnel Insertion/Extraction Training – Swimmer/Diver	Divers and swimmer infiltrate harbors, beaches, or moored vessels and conduct a variety of tasks.
Underwater Construction Team Training	Navy divers conduct underwater repair and construction.
Mine Warfare	
Airborne Mine Countermeasures – Mine Detection	Helicopter aircrews detect mines using towed or laser mine detection systems.
Airborne Mine Countermeasures – Towed Mine Neutralization	Helicopter crews tow systems through the water, which are designed to disable or trigger mines.
Civilian Port Defense – Homeland Security Anti-Terrorism/Force Protection Exercise	Maritime security personnel train to protect civilian ports against enemy efforts to interfere with access to those ports.
Coordinated Unit-Level Helicopter Airborne Mine Countermeasure Exercise	A detachment of helicopter aircrews train as a unit in the use of airborne mine countermeasures, such as towed mine detection and neutralization systems.
Mine Countermeasures – Mine Neutralization – Remotely Operated Vehicles	Ship, small boat, and helicopter crews locate and disable mines using remotely operated underwater vehicles.
Mine Countermeasures – Ship Sonar	Ship crews detect and avoid mines while navigating restricted areas or channels using active sonar.
Mine Laying	Fixed-winged aircraft drop non-explosive mine shapes.
Mine Neutralization – Explosive Ordnance Disposal	Personnel place limpet mines or disable threat mines using explosive charges.
Underwater Mine Countermeasures Raise, Tow, Beach, and Exploitation Operations	Personnel locate mines, perform mine neutralization, raise and tow the mines to the beach, and conduct exploitation operations for intelligence gathering.
Surface Warfare	
Bombing Exercise Air-to-Surface	Fixed-wing aircrews deliver bombs against surface targets.
Fast Attack Craft and Fast Inshore Attack Craft Exercise	Navy surface ship and helicopter crews defend against small boat attacks.
Gunnery Exercise Air-to-Surface Medium-Caliber	Fixed-wing and helicopter aircrews fire medium-caliber guns at surface targets.
Gunnery Exercise Air-to-Surface Small-Caliber	Helicopter and tilt-rotor aircrews use small-caliber guns to engage surface targets.
Gunnery Exercise Surface-to-Surface Boat Medium-Caliber	Small boat crews fire medium-caliber guns at surface targets.

Activity Name	Activity Description
Gunnery Exercise Surface-to-Surface Boat Small-Caliber	Small boat crews fire small-caliber guns at surface targets.
Gunnery Exercise Surface-to-Surface Ship Large-Caliber	Surface ship crews fire large-caliber guns at surface targets.
Gunnery Exercise Surface-to-Surface Ship Medium-Caliber	Surface ship crews fire medium-caliber guns at surface targets.
Gunnery Exercise Surface-to-Surface Ship Small-Caliber	Surface ship crews fire small-caliber guns at surface targets.
Integrated Live Fire Exercise	Naval forces defend against a swarm of surface threats (ships or small boats) with bombs, missiles, rockets, and small-, medium- and large-caliber guns.
Laser Targeting – Aircraft	Fixed-wing and helicopter aircrews illuminate targets with targeting and directed energy lasers.
Laser Targeting – Ship	Surface ship crews illuminate air and surface targets with targeting and directed energy lasers.
Maritime Security Operations	Helicopter, surface ship, and small boat crews conduct a suite of maritime security operations.
Missile Exercise Air-to-Surface	Fixed-wing and helicopter aircrews fire air-to-surface missiles at surface targets.
Missile Exercise Air-to-Surface Rocket	Helicopter aircrews fire both precision-guided and unguided rockets at surface targets.
Missile Exercise Surface-to-Surface	Surface ship crews defend against surface threats (ships or small boats) and engage them with missiles.
Sinking Exercise	Aircraft, ship, and submarine crews deliberately sink a seaborne target, usually a decommissioned ship (made environmentally safe for sinking according to U.S. Environmental Protection Agency standards), with a variety of munitions.
Other Training Activities	
Elevated Causeway System	A temporary pier is constructed off the beach. Supporting pilings are driven into the sand using an impact hammer and then later removed via vibratory pile extraction.
Precision Anchoring	Anchors are released in designated locations or moored to a buoy.
Search and Rescue	Surface ships, small boats, and helicopter rescue personnel at sea.
Submarine Navigation	Submarine crews operate sonar for navigation and object detection while transiting into and out of port during reduced visibility.
Submarine Sonar Maintenance and Systems Checks	Maintenance of submarine sonar systems is conducted pierside or at sea.
Submarine Under Ice Certification	Submarine crews train to operate under ice. Ice conditions are simulated during training and certification events.
Surface Ship Object Detection	Surface ship crews operate sonar for navigation and object detection while transiting in and out of port during reduced visibility.
Surface Ship Sonar Maintenance and Systems Checks	Maintenance of surface ship sonar systems is conducted pierside or at sea.
Waterborne Training	Small boat crews conduct a variety of training, including launch and recovery, mooring to buoys, anchoring, and maneuvering. Small boats include rigid hull inflatable boats, and riverine patrol, assault and command boats up to approximately 50 feet in length.

The Navy proposes to conduct military readiness training activities into the reasonably foreseeable future, as necessary to meet current and future readiness requirements. These military readiness training activities include new activities, as well as activities that are currently ongoing and have historically occurred in the action area. For the purposes of this consultation and for the proposed MMPA rule, the Navy identified the number and duration of training activities that could occur over every 5-year period, beginning in November 2018. The proposed activity levels consider fluctuations in training cycles and deployment schedules that do not follow a traditional annual calendar but instead are influenced by in-theater demands and other external factors. The proposed activities account for force structure changes and include training with new aircraft, vessels, unmanned/autonomous systems, and weapon systems that will be introduced to the fleets after November 2018. The numbers of all proposed training activities and their proposed locations are provided in Table 13. The proposed training activities in Table 13 reflect a representative year of training to account for the natural fluctuation of training cycles and deployment schedules that generally influences the maximum level of training that may occur year after year in any 5-year period.

Table 13. Proposed Training Activities.

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
Major Training Exercise – Large Integrated Anti-Submarine Warfare			
Composite Training Unit Exercise	2–3	12	Virginia Capes RC Navy Cherry Point RC Jacksonville RC
Major Training Exercise – Medium Integrated Anti-Submarine Warfare			
Fleet Exercise/Sustainment Exercise	4	20	Jacksonville RC
	2	10	Virginia Capes RC
Integrated/Coordinated Training			
Small Integrated Anti-Submarine Training	6	30	Jacksonville RC
	3	15	Navy Cherry Point RC
	3	15	Virginia Capes RC
Medium Coordinated Anti-Submarine Warfare Training	2	10	Jacksonville RC
	1	5	Navy Cherry Point RC
	1	5	Virginia Capes RC
Small Coordinated Anti-Submarine Warfare Training	4	20	Jacksonville RC
	5	25	Navy Cherry Point RC
	5	25	Virginia Capes RC
Air Warfare			
	1,270	6,350	Jacksonville RC
	6,300	31,500	Key West RC
	1,155	5,775	Navy Cherry Point RC
	1,200	6,000	Virginia Capes RC
Air Defense Exercise	85	425	Gulf of Mexico RC
	5,157	25,785	Jacksonville RC
	5,166	25,830	Navy Cherry Point RC
	3,425	17,125	Virginia Capes RC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
Gunnery Exercise Air-to-Air Medium-Caliber	75	375	Jacksonville RC
	70	350	Key West RC
	40	200	Navy Cherry Point RC
	120	600	Virginia Capes RC
Gunnery Exercise Surface-to-Air Large Caliber	7	35	Jacksonville RC
	25	125	Virginia Capes RC
Gunnery Exercise Surface-to-Air Medium Caliber	10	50	Other AFTT Areas
	31	155	Jacksonville RC
	23	115	Navy Cherry Point RC
	59	295	Virginia Capes RC
Missile Exercise Air-to-Air	48	240	Jacksonville RC
	8	40	Key West RC
	48	240	Navy Cherry Point RC
	40	200	Virginia Capes RC
Missile Exercise Surface-to-Air	2	10	Gulf of Mexico RC
	5	20	Jacksonville RC
	2	10	Navy Cherry Point RC
	2	10	Northeast RC
	30	50	Virginia Capes RC
Missile Exercise – Man-Portable Air Defense System	5	25	Navy Cherry Point RC
Amphibious Warfare			
Amphibious Assault	5	25	Navy Cherry Point RC
Amphibious Marine Expeditionary Unit Integration Exercise	1	5	Navy Cherry Point RC
Amphibious Raid	20	100	Jacksonville RC
	34	162	Navy Cherry Point RC
Amphibious Ready Group Marine Expeditionary Unit Exercise	1	5	Navy Cherry Point RC
Amphibious Vehicle Maneuvers	186	930	Virginia Capes RC
	2	10	Jacksonville RC
Humanitarian Assistance Operations	1	5	Navy Cherry Point RC
Marine Expeditionary Unit Certification Exercise	5	25	Navy Cherry Point RC
Naval Surface Fire Support Exercise – At Sea	4	20	Gulf of Mexico
	12	60	Jacksonville RC
	2	10	Navy Cherry Point RC
	38	190	Virginia Capes RC
Naval Surface Fire Support Exercise - Land–Based Target	7	35	Navy Cherry Point RC
Anti-Submarine Warfare			
	14	70	Jacksonville RC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
Anti-Submarine Warfare Torpedo Exercise – Helicopter	4	20	Virginia Capes RC
Anti-Submarine Warfare Torpedo Exercise – Maritime Patrol Aircraft	14	70	Jacksonville RC
	4	20	Virginia Capes RC
Anti-Submarine Warfare Torpedo Exercise –Ship	16	80	Jacksonville RC
	5	25	Virginia Capes RC
Anti-Submarine Warfare Torpedo Exercise – Submarine	12	60	Jacksonville RC
	6	30	Northeast RC
	2	10	Virginia Capes RC
Anti-Submarine Warfare Tracking Exercise – Helicopter	24	120	Other AFTT Areas
	370	1,850	Jacksonville RC
	12	60	Navy Cherry Point RC
	8	40	Virginia Capes RC
Anti-Submarine Warfare Tracking Exercise – Maritime Patrol Aircraft	90	450	Northeast RC
	176	880	Virginia Capes RC
	525	2,625	Jacksonville RC
	46	230	Navy Cherry Point RC
Anti-Submarine Warfare Tracking Exercise – Ship	5*	25*	Northeast RC
	110*	550*	Other AFTT Areas
	5*	25*	Gulf of Mexico RC
	440*	2,200	Jacksonville RC
	55*	275	Navy Cherry Point RC
	220*	1,100	Virginia Capes RC
Anti-Submarine Warfare Tracking Exercise – Submarine	44	220	Other AFTT Areas
	13	65	Jacksonville RC
	1	5	Navy Cherry Point RC
	18	90	Northeast RC
	6	30	Virginia Capes RC
Electronic Warfare			
Counter Targeting Chaff Exercise – Aircraft	18	90	Gulf of Mexico RC
	2,990	14,950	Jacksonville RC
	3,000	15,000	Key West RC
	1,610	8,050	Navy Cherry Point RC
	130	650	Virginia Capes RC
Counter Targeting Chaff Exercise – Ship	5	25	Gulf of Mexico RC
	5	25	Jacksonville RC
	5	25	Navy Cherry Point RC
	50	250	Virginia Capes RC
Counter Targeting Flare Exercise	92	460	Gulf of Mexico RC
	1,900	9,500	Jacksonville RC
	1,550	7,750	Key West RC
	1,115	5,575	Navy Cherry Point RC
	50	250	Virginia Capes RC
Electronic Warfare Operations	181	905	Jacksonville RC
	2,620	13,100	Navy Cherry Point RC
	302	1,510	Virginia Capes RC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
High-Speed Anti-Radiation Missile Exercise	4	20	Jacksonville RC
	10	50	Navy Cherry Point RC
	11	55	Virginia Capes RC
Expeditionary Warfare			
Dive and Salvage Operations	16	80	Gulf of Mexico RC
	60	300	Jacksonville RC
	8	40	Key West RC
	16	80	Navy Cherry Point RC
	30	150	Virginia Capes RC
Maritime Security Operations – Anti-Swimmer Grenades	2	10	Gulf of Mexico RC
	2	10	Jacksonville RC
	2	10	Navy Cherry Point RC
	4	20	Northeast RC
	5	25	Virginia Capes RC
Personnel Insertion/ Extraction – Air	10	50	Jacksonville RC
	10	50	Key West
	2,164	10,820	Virginia Capes RC
Personnel Insertion/ Extraction – Surface and Subsurface	2	10	Northeast RC
	5	25	Gulf of Mexico RC
	1	5	Jacksonville RC
	360	1,800	Virginia Capes RC
Personnel Insertion/ Extraction – Swimmer/Diver	42	210	Virginia Capes RC
Underwater Construction Team Training	8	40	Gulf of Mexico RC
	4	20	Jacksonville RC
	4	20	Key West RC
	8	40	Virginia Capes RC
Mine Warfare			
Airborne Mine Countermeasure - Mine Detection	66	330	Gulf of Mexico RC
	317	1,585	Jacksonville RC
	371	1,855	Navy Cherry Point RC
	244	1,220	NSWC Panama City
	1,540	7,700	Virginia Capes RC
Airborne Mine Countermeasures – Towed Mine Neutralization	50	250	Gulf of Mexico RC
	100	500	Jacksonville RC
	108	540	Navy Cherry Point RC
	510	2,550	Virginia Capes RC
Civilian Port Defense – Homeland Security Anti-Terrorism/Force Protection Exercise	1	3	Beaumont, TX Boston, MA Corpus Christi, TX Delaware Bay, DE Earle, NJ Gulf of Mexico RC Hampton Roads, VA Jacksonville RC Kings Bay, GA NS Mayport Morehead City, NC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
			Port Canaveral, FL Savannah, GA Tampa, FL Virginia Capes RC Wilmington, DE
Coordinated Unit Level Helicopter Airborne Mine Countermeasure Exercise	2	10	Gulf of Mexico RC
	2	10	Jacksonville RC
	2	10	Navy Cherry Point RC
	2	10	Virginia Capes RC
Mine Countermeasures – Mine Neutralization – Remotely Operated Vehicle	132	660	Gulf of Mexico RC
	71	355	Jacksonville RC
	71	355	Navy Cherry Point RC
	630	3,150	Virginia Capes RC
Mine Countermeasures – Ship Sonar	22	110	Gulf of Mexico RC
	53	265	Jacksonville RC
	53	265	Virginia Capes RC
Mine Laying	1	5	Jacksonville RC
	2	10	Navy Cherry Point RC
	4	20	Virginia Capes RC
Mine Neutralization – Explosive Ordnance Disposal	6	30	Lower Chesapeake Bay
	16	80	Gulf of Mexico RC
	20	100	Jacksonville RC
	17	85	Key West RC
	16	80	Navy Cherry Point RC
	524	2,620	Virginia Capes RC
Underwater Mine Countermeasures Raise, Tow, Beach, and Exploitation Operations	56	280	Gulf of Mexico RC
	78	390	Jacksonville RC
	8	40	Key West RC
	24	120	Navy Cherry Point RC
	446	2,230	Virginia Capes RC
Surface Warfare			
Bombing Exercise Air-to-Surface	67	335	Gulf of Mexico RC
	434	2,170	Jacksonville RC
	108	540	Navy Cherry Point RC
	329	1,645	Virginia Capes RC
Fast Attack Craft and Fast Inshore Attack Craft Exercise	25	125	Jacksonville RC
	25	125	Virginia Capes RC
Gunnery Exercise Air-to-Surface Medium-Caliber	30	150	Gulf of Mexico RC
	495	2,475	Jacksonville RC
	395	1,975	Navy Cherry Point RC
	720	3,600	Virginia Capes RC
Gunnery Exercise Air-to-Surface Small-Caliber	200	1,000	Jacksonville RC
	130	650	Navy Cherry Point RC
	560	2,800	Virginia Capes RC
Gunnery Exercise Surface-to-Surface Boat Medium-Caliber	6	30	Gulf of Mexico RC
	26	130	Jacksonville RC
	128	640	Navy Cherry Point RC
	2	10	Northeast RC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
	260	1,300	Virginia Capes RC
Gunnery Exercise Surface-to-Surface Boat Small-Caliber	67	335	Gulf of Mexico RC
	84	420	Jacksonville RC
	92	460	Navy Cherry Point RC
	18	90	Northeast RC
	330	650	Virginia Capes RC
Gunnery Exercise Surface-to-Surface Ship Large-Caliber	10	50	Other AFTT Areas
	9	45	Gulf of Mexico RC
	51	255	Jacksonville RC
	35	175	Navy Cherry Point RC
	75	375	Virginia Capes RC
Gunnery Exercise Surface-to-Surface Ship Medium-Caliber	41	205	Other AFTT Areas
	33	165	Gulf of Mexico RC
	161	805	Jacksonville RC
	72	360	Navy Cherry Point RC
	321	1,605	Virginia Capes RC
Gunnery Exercise Surface-to-Surface Ship Small-Caliber	50	250	Other AFTT Areas
	10	50	Gulf of Mexico RC
	300	1,500	Jacksonville RC
	20	100	Navy Cherry Point RC
	450	2,250	Virginia Capes RC
Integrated Live Fire Exercise	2	10	Jacksonville RC
	2	10	Virginia Capes RC
Laser Targeting – Aircraft	315	1,575	Jacksonville RC
	272	1,360	Virginia Capes RC
Laser Targeting – Ship	4	20	Jacksonville RC
	4	20	Virginia Capes RC
Maritime Security Operations	59	245	Gulf of Mexico RC
	210	1,050	Jacksonville RC
	75	375	Navy Cherry Point RC
	13	65	Northeast RC
	895	4,475	Virginia Capes RC
Missile Exercise Air-to-Surface	102	510	Jacksonville RC
	52	260	Navy Cherry Point RC
	88	440	Virginia Capes RC
Missile Exercise Air-to-Surface – Rocket	10	50	Gulf of Mexico RC
	102	510	Jacksonville RC
	10	50	Navy Cherry Point RC
	92	460	Virginia Capes RC
Missile Exercise Surface-to-Surface	16	80	Jacksonville RC
	12	60	Virginia Capes RC
Sinking Exercise	1	5	SINKEX Box
Other Training Activities			
Elevated Causeway System	1	5	Lower Chesapeake Bay
	1	5	Navy Cherry Point RC
Precision Anchoring	9	45	Gulf of Mexico RC
	231	1,155	Jacksonville RC
	710	3,550	Virginia Capes RC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
Search and Rescue	776	3,880	Jacksonville RC
	1,176	5,880	Virginia Capes RC
Submarine Navigation	169	845	NSB New London
	3	15	NSB Kings Bay
	3	15	NS Mayport
	84	420	NS Norfolk
	23	115	Port Canaveral, FL
Submarine Sonar Maintenance	12	60	Other AFTT Areas
	66	330	NSB New London
	9	45	Jacksonville RC
	2	10	NSB Kings Bay
	34	170	NS Norfolk
	86	430	Northeast RC
	2	10	Port Canaveral, FL
	13	63	Navy Cherry Point RC
	47	233	Virginia Capes RC
Submarine Under Ice Certification	3	15	Jacksonville RC
	3	15	Navy Cherry Point RC
	9	45	Northeast RC
	9	45	Virginia Capes RC
Activity Name	***Annual # of Activities[1]***	***5-Year # of Activities***	***Location[2]***
Surface Ship Object Detection	76	380	NS Mayport
	162	810	NS Norfolk
Surface Ship Sonar Maintenance	50	250	Jacksonville RC
	50	250	NS Mayport
	120	600	Navy Cherry Point RC
	235	1,175	NS Norfolk
	120	600	Virginia Capes RC
Waterborne Training	42	210	Gulf of Mexico RC
	55	275	Jacksonville RC
	141	705	Northeast RC
	110	550	Virginia Capes RC

[1] For activities where the maximum number of events varies between years, a range is provided to indicate the "representative–maximum" number of events. For activities where no variation is anticipated, only the maximum number of events within a single year is provided.

[2] Locations given are areas where activities typically occur. However, activities could be conducted in other locations within the action area. Where multiple locations are provided within a single cell, the number of activities could occur in any of the locations, not in each of the locations.

** For anti-submarine warfare tracking exercise – Ship, 50 percent of requirements are met through synthetic training or other training exercises.*

AFTT: Atlantic Fleet Training and Testing; NS: Naval Station; NSB: Naval Submarine Base; NSWC: Naval Surface Warfare Center; Gulf of Mexico: Gulf of Mexico; Jacksonville: Jacksonville; RC: Range Complex; SINKEX: sinking exercises; Virginia Capes: Virginia Capes

3.3.2 Testing Activities

The Navy's research and acquisition community engages in a broad spectrum of testing activities in support of the fleet. These activities include, but are not limited to, basic and applied scientific research and technology development; testing, evaluation, and maintenance of systems (e.g., missiles, radar, and sonar) and platforms (e.g., surface ships, submarines, and aircraft); and acquisition of systems and platforms to support Navy missions. The individual commands within the research and acquisition community included in the proposed action are Naval Air Systems Command, Naval Sea Systems Command, and the Office of Naval Research.

Testing activities occur in response to emerging science or fleet operational needs. For example, future Navy experiments to develop a better understanding of ocean currents and future Navy operations within a specific geographic area may require development of modified Navy assets to address local conditions. Such modifications must be tested in the field to ensure they meet fleet needs and requirements. Accordingly, generic descriptions of some of these activities are provided below.

Some testing activities are similar to training activities conducted by the fleet. For example, both the fleet and the research and acquisition community fire torpedoes. While the firing of a torpedo might look identical to an observer, the difference is in the purpose of the firing. The fleet might fire the torpedo to practice the procedures for such a firing, whereas the research and acquisition community might be assessing a new torpedo guidance technology or testing it to ensure the torpedo meets performance specifications and operational requirements.

3.3.2.1 Naval Air Systems Command Testing Activities

The majority of testing activities conducted by Naval Air Systems Command are similar to fleet training activities, and many platforms and systems currently being tested are already being used by the fleet or will ultimately be integrated into fleet training activities. Naval Air Systems Command activities include, but are not limited to, the testing of new aircraft platforms (e.g., the F-35 Joint Strike Fighter aircraft), weapons, and systems (e.g., newly developed sonobuoys) that will ultimately be integrated into fleet training activities. In addition to the testing of new platforms, weapons, and systems, Naval Air Systems Command also conducts lot acceptance testing of weapons and systems, such as sonobuoys. Some testing activities may be conducted in different locations and in a different manner than similar fleet training activities and, therefore, the analysis for those events and the potential environmental effects may differ.

Table 13 describes Naval Air Systems Command's testing activities and Table 14 provides a list of the proposed testing activities.

Table 13. Description of each of Naval Air Systems Command's proposed testing activities (Navy 2017a).

Activity Name	Activity Description
Air Warfare	
Air Combat Maneuver Test	Aircrews engage in flight maneuvers designed to gain a tactical advantage during combat.
Air Platform Weapons Integration Test	Test performed to quantify the compatibility of weapons with the aircraft from which they would be launched or released. Non-explosive weapons or shapes are used.
Air Platform-Vehicle Test	Test performed to quantify the flying qualities, handling, airworthiness, stability, controllability, and integrity of an air platform or vehicle. No explosive weapons are released during an air platform/vehicle test.
Air-to-Air Weapons System Test	Test to evaluate the effectiveness of air-launched weapons against designated air targets.
Air-to-Air Gunnery Test – Medium-Caliber	Test performed to evaluate the effectiveness of air-to-air guns against designated airborne targets. Fixed-wing aircraft may be used.
Air-to-Air Missile Test	Test performed to evaluate the effectiveness of air-launched missiles against designated airborne targets. Fixed-wing aircraft will be used.
Intelligence, Surveillance, and Reconnaissance Test	Aircrews use all available sensors to collect data on threat vessels.
Anti-Submarine Warfare	
Anti-Submarine Warfare Torpedo Test	This event is similar to the training event torpedo exercise. Test evaluates anti-submarine warfare systems onboard rotary-wing (e.g., helicopter) and fixed-wing aircraft and the ability to search for, detect, classify, localize, track, and attack a submarine or similar target.
Anti-Submarine Warfare Tracking Test – Helicopter	This event is similar to the training event anti-submarine warfare tracking exercise – helicopter. The test evaluates the sensors and systems used to detect and track submarines and to ensure that helicopter systems used to deploy the tracking system perform to specifications.
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft	The test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines and to ensure that aircraft systems used to deploy the tracking systems perform to specifications and meet operational requirements.
Kilo Dip	Functional check of a helicopter deployed dipping sonar system prior to conducting a testing or training event using the dipping sonar system.
Sonobuoy Lot Acceptance Test	Sonobuoys are deployed from surface vessels and aircraft to verify the integrity and performance of a production lot or group of sonobuoys in advance of delivery to the fleet for operational use.
Electronic Warfare	
Chaff Test	This event is similar to the training event chaff exercise. Chaff tests evaluate newly developed or enhanced chaff, chaff dispensing equipment, or modified aircraft systems against chaff deployment. Tests may also train pilots and aircrews in the use of new chaff dispensing equipment. Chaff tests are often conducted with flare tests and air combat maneuver events, as well as other test events, and are not typically conducted as standalone tests.
Electronic Systems Evaluation	Test that evaluates the effectiveness of electronic systems to control, deny, or monitor critical portions of the electromagnetic spectrum. In

Activity Name	Activity Description
	general, electronic warfare testing will assess the performance of three types of electronic warfare systems: electronic attack, electronic protect, and electronic support.
Flare Test	This event is similar to the training event flare exercise. Flare tests evaluate newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems against flare deployment. Tests may also train pilots and aircrews in the use of newly developed or modified flare deployment systems. Flare tests are often conducted with chaff tests and air combat maneuver events, as well as other test events, and are not typically conducted as standalone tests.
Mine Warfare	
Airborne Dipping Sonar Minehunting Test	A mine-hunting dipping sonar system that is deployed from a helicopter and uses high-frequency sonar for the detection and classification of bottom and moored mines.
Airborne Laser Based Mine Detection System Test	An airborne mine hunting test of a laser based mine detection system that is operated from a helicopter and evaluates the system's ability to detect, classify, and fix the location of floating mines and mines moored near the surface. The system uses a low-energy laser to locate mines.
Airborne Mine Neutralization System Test	A test of the airborne mine neutralization system evaluates the system's ability to detect and destroy mines from an airborne mine countermeasures capable helicopter. The airborne mine neutralization system uses up to four unmanned underwater vehicles equipped with high-frequency sonar, video cameras, and explosive and non-explosive neutralizers.
Airborne Sonobuoy Minehunting Test	A mine-hunting system made up of a field of sonobuoys deployed by a helicopter. A field of sonobuoys, using high-frequency sonar, is used to detect and classify bottom and moored mines.
Mine Laying Test	Fixed-wing aircraft evaluate the performance of mine laying equipment and software systems to lay mines. A mine test may also train aircrews in laying mines using new or enhanced mine deployment system.
Surface Warfare	
Air-to-Surface Bombing Test	This event is similar to the training event bombing exercise air-to-surface. Fixed-wing aircraft test the delivery of bombs against surface maritime targets with the goal of evaluating the bomb, the bomb carry and delivery system, and any associated systems that may have been newly developed or enhanced.
Air-to-Surface Gunnery Test	This event is similar to the training event gunnery exercise air-to-surface. Fixed-wing and rotary-wing aircrews evaluate new or enhanced aircraft guns against surface maritime targets to test that the guns, gun ammunition, or associated systems meet required specifications or to train aircrews in the operation of a new or enhanced weapon system.
Air-to-Surface Missile Test	This event is similar to the training event missile exercise air-to-surface. Test may involve both fixed-wing and rotary-wing aircraft launching missiles at surface maritime targets to evaluate the weapon system or as part of another system's integration test.
High-Energy Laser Weapons Test	High-energy laser weapons tests evaluate the specifications, integration, and performance of an aircraft-mounted, approximately 25 kilowatt, high-energy laser used to disable small surface vessels.
Laser Targeting Test	Aircrews illuminate enemy targets with lasers.

Activity Name	Activity Description
Rocket Test	Rocket tests evaluate the integration, accuracy, performance, and safe separation of guided and unguided 2.75 inch rockets fired from a hovering or forward-flying helicopter.
Other Testing Activities	
Acoustic and Oceanographic Research	Active transmissions within the band 10 Hz–100 kHz from sources deployed from ships and aircraft
Air Platform Shipboard Integrate Test	Fixed-wing and rotary-wing aircraft are tested to determine operability from shipboard platforms, performance of shipboard physical operations, and to verify and evaluate communications and tactical data links.
Maritime Security	Maritime patrol aircraft participate in maritime security activities and fleet training events. Aircraft identify, track, and monitor foreign merchant vessels suspected of non-compliance with United Nations-allied sanctions or conflict rules of engagement.
Shipboard Electronic Systems Evaluation	Tests measure ship antenna radiation patterns and test communication systems with a variety of aircraft
Undersea Range System Test	Following installation of a Navy underwater warfare training and testing range, tests of the nodes (components of the range) will be conducted to include node surveys and testing of node transmission functionality.

Table 14. Naval Air Systems Command proposed testing activities.

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
Air Warfare			
Air Combat Maneuver Test	550	2,750	Virginia Capes RC
Air Platform Weapons Integration Test	40	200	Virginia Capes RC
Air Platform-Vehicle Test	12	60	Gulf of Mexico RC
	9	45	Jacksonville RC
	9	45	Key West RC
	9	45	Navy Cherry Point RC
	190	950	Virginia Capes RC
Air-to-Air Weapons System Test	10	50	Gulf of Mexico RC
Air-to-Air Gunnery Test – Medium-Caliber	55	275	Virginia Capes RC
Air-to-Air Missile Test	83	415	Virginia Capes RC
Intelligence, Surveillance, and Reconnaissance Test	7	35	Jacksonville RC
	9	45	Navy Cherry Point RC
	406	2,030	Virginia Capes RC
Anti-Submarine Warfare			
Anti-Submarine Warfare Torpedo Test	20–43	146	Jacksonville RC
	40–121	362	Virginia Capes RC
Anti-Submarine Warfare Tracking Test –	4–6	24	Gulf of Mexico RC
	0–12	24	Jacksonville RC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
Helicopter	2–27	39	Key West RC
	28–110	304	Northeast RC
	137–280	951	Virginia Capes RC
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft	10–15	60	Gulf of Mexico RC
	19	95	Jacksonville RC
	10–12	54	Key West RC
	14–15	72	Navy Cherry Point RC
	36–45	198	Northeast RC
	25	125	Virginia Capes RC
Kilo Dip	2–6	14	Gulf of Mexico RC
	0–6	6	Jacksonville RC
	0–6	6	Key West RC
	0–4	8	Northeast RC
	20–40	140	Virginia Capes RC
Sonobuoy Lot Acceptance Test	160	800	Key West RC
Electronic Warfare			
Chaff Test	20	100	Gulf of Mexico RC
	4	20	Jacksonville RC
	24	120	Virginia Capes RC
Electronic Systems Evaluation	2	10	Jacksonville RC
	61	305	Virginia Capes RC
Flare Test	10	50	Gulf of Mexico RC
	20	100	Virginia Capes RC
Mine Warfare			
Airborne Dipping Sonar Minehunting Test	16–32	96	NSWC Panama City
	6–18	42	Virginia Capes RC
Airborne Laser Based Mine Detection System Test	40	200	NSWC Panama City
	50	250	Virginia Capes RC
Airborne Mine Neutralization System Test	20–27	107	NSWC Panama City
	25–45	145	Virginia Capes RC
Airborne Sonobuoy Minehunting Test	52	260	NSWC Panama City
	24	120	Virginia Capes RC
Mine Laying Test	1	5	Jacksonville RC
	2	10	Virginia Capes RC
Surface Warfare			
Air-to-Surface Bombing Test	20	100	Virginia Capes RC
Air-to-Surface Gunnery Test	25–55	215	Jacksonville RC
	110–140	640	Virginia Capes RC
Air-to-Surface Missile Test	0–10	20	Gulf of Mexico RC
	29–38	167	Jacksonville RC
	117–148	663	Virginia Capes RC
High Energy Laser Weapons Test	108	540	Virginia Capes RC
Laser Targeting Test	5	25	Virginia Capes RC
Rocket Test	15–19	87	Jacksonville RC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
	31–35	167	Virginia Capes RC
Other Testing Activities			
Undersea Range System Test	4–20	42	Jacksonville RC
Acoustic and Oceanographic Research	1	5	Gulf of Mexico RC
	1	5	Jacksonville RC
	1	5	Key West RC
	1	5	Northeast RC
	1	5	Virginia Capes RC
Air Platform Shipboard Integrate Test	126	630	Virginia Capes RC
Maritime Security	12	60	Jacksonville RC
	12	60	Navy Cherry Point RC
	20	100	Virginia Capes RC
Shipboard Electronic Systems Evaluation	24	120	Gulf of Mexico RC
	24	120	Jacksonville RC
	24	120	Key West RC
	26	130	Virginia Capes RC

[1] For activities where the maximum number of events varies between years, a range is provided to indicate the "representative–maximum" number of events. For activities where no variation is anticipated, only the maximum number of events within a single year is provided.
[2] Locations given are areas where activities typically occur. However, activities could be conducted in other locations within the action area.
Gulf of Mexico: Gulf of Mexico; Jacksonville: Jacksonville; NSWC: Naval Surface Warfare Center; RC: Range Complex; Virginia Capes: Virginia Capes

3.3.2.2 Naval Sea Systems Command Testing Activities

Naval Sea Systems Command activities are generally aligned with the primary mission areas used by the fleets. Additional activities include, but are not limited to, vessel evaluation, unmanned systems, and other testing activities. Testing activities are conducted throughout the life of a Navy ship, from construction through deactivation from the fleet, as part of verification of performance and mission capabilities. Activities include pierside and at-sea testing of ship systems, including sonar, acoustic countermeasures, radars, launch systems, weapons, unmanned systems, and radio equipment; tests to determine how the ship performs at sea (sea trials); development and operational testing and evaluation programs for new technologies and systems; and testing on all ships and systems that have undergone overhaul or maintenance.

Additionally, one ship of each new class (or major upgrade) of combat ships constructed for the Navy typically undergoes an at-sea ship shock trial. A ship shock trial consists of a series of underwater detonations that send shock waves through the ship's hull to simulate near misses during combat. A shock trial allows the Navy to assess the survivability of the hull and ship's systems in a combat environment as well as the capability of the ship to protect the crew.

Table 14 describes Naval Sea Systems Command's testing activities while Table 15 provides a list of the proposed testing activities.

Table 14. A description of each of Naval Systems Command's testing activities (Navy 2017a).

Activity Name	Activity Description
Anti-Submarine Warfare	
Anti-Submarine Warfare Mission Package Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial systems) detect, localize, and attack submarines.
At-Sea Sonar Testing	At-sea testing to ensure systems are fully functional in an open ocean environment.
Countermeasure Testing	Countermeasure testing involves the testing of systems that will detect, localize, track, and attack incoming weapons including marine vessel targets. Testing includes surface ship torpedo defense systems and marine vessel stopping payloads.
Pierside Sonar Testing	Pierside testing to ensure systems are fully functional in a controlled pierside environment prior to at-sea test activities.
Submarine Sonar Testing/ Maintenance	Pierside testing of submarine systems occurs periodically following major maintenance periods and for routine maintenance.
Surface Ship Sonar Testing/ Maintenance	Pierside and at-sea testing of ship systems occur periodically following major maintenance periods and for routine maintenance.
Torpedo (Explosive) Testing	Air, surface, or submarine crews employ explosive and non-explosive torpedoes against artificial targets.
Torpedo (Non-Explosive) Testing	Air, surface, or submarine crews employ non-explosive torpedoes against submarines or surface vessels.
Electronic Warfare	
Radar and Other System Testing	Test may include radiation of military or commercial radar communication systems (or simulators), or high-energy lasers. Testing may occur aboard a ship against drones, small boats, rockets, missiles, or other targets.
Mine Warfare	
Mine Countermeasure and Neutralization Testing	Air, surface, and subsurface vessels neutralize threat mines and mine-like objects.
Mine Countermeasure Mission Package Testing	Vessels and associated aircraft conduct mine countermeasure operations.
Mine Detection and Classification Testing	Air, surface, and subsurface vessels and systems detect, classify, and avoid mines and mine-like objects. Vessels also assess their potential susceptibility to mines and mine-like objects.
Surface Warfare	
Gun Testing – Large-Caliber	Crews defend against targets with large-caliber guns.
Gun Testing – Medium-Caliber	Surface crews defend against targets with medium-caliber guns.
Gun Testing – Small-Caliber	Surface crews defend against targets with small-caliber guns.
Kinetic Energy Weapon Testing	A kinetic energy weapon uses stored energy released in a burst to accelerate a projectile.
Missile and Rocket Testing	Missile and rocket testing includes various missiles or rockets fired from submarines and surface combatants. Testing of the launching system and ship defense is performed.
Unmanned Systems	
Underwater Search, Deployment, and Recovery	Various underwater, bottom crawling, robotic vehicles are utilized in underwater search, recovery, installation, and scanning activities.

Activity Name	Activity Description
Unmanned Aerial System Testing	Unmanned aerial systems are launched from a platform (e.g., fixed platform or submerged submarine) to test the capability to extend the surveillance and communications range of unmanned underwater vehicles, manned and unmanned surface vehicles, and submarines.
Unmanned Surface Vehicle System Testing	Testing involves the development or upgrade of unmanned surface vehicles. This may include testing of mine detection capabilities, evaluating the basic functions of individual platforms, or complex events with multiple vehicles.
Unmanned Underwater Vehicle Testing	Testing involves the development or upgrade of unmanned underwater vehicles. This may include testing of mine detection capabilities, evaluating the basic functions of individual platforms, or complex events with multiple vehicles.
Vessel Evaluation	
Aircraft Carrier Sea Trials – Propulsion Testing	Ship is run at high speeds in various formations (e.g., straight-line and reciprocal paths).
Air Defense Testing	Test the ship's capability to detect, identify, track, and successfully engage live and simulated targets. Gun systems are tested using explosive or non-explosive rounds.
Hydrodynamic and Maneuverability Testing	Submarines maneuver in the submerged operating environment.
In-Port Maintenance Testing	Each combat system is tested to ensure they are functioning in a technically acceptable manner and are operationally ready to support at-sea testing.
Large Ship Shock Trial	Underwater detonations are used to test new ships or major upgrades.
Propulsion Testing	Ship is run at high speeds in various formations (e.g., straight-line and reciprocal paths).
Signature Analysis Operations	Surface ship and submarine testing of electromagnetic, acoustic, optical, and radar signature measurements.
Small Ship Shock Trial	Underwater detonations are used to test new ships or major upgrades.
Submarine Sea Trials – Propulsion Testing	Submarine is run at high speeds in various formations and depths.
Submarine Sea Trials – Weapons System Testing	Submarine weapons and sonar systems are tested at-sea to meet integrated combat system certification requirements.
Surface Warfare Testing	Tests capability of shipboard sensors to detect, track, and engage surface targets. Testing may include ships defending against surface targets using explosive and non-explosive rounds, gun system structural test firing and demonstration of the response to Call for Fire against land-based targets (simulated by sea-based locations).
Total Ship Survivability Trials	Series of simulated "realistic" weapon hit scenarios with resulting damage and recoverability exercises against an aircraft carrier.
Undersea Warfare Testing	Ships demonstrate capability of countermeasure systems and underwater surveillance, weapons engagement, and communications systems. This tests ships' ability to detect, track, and engage underwater targets.
Vessel Signature Evaluation	Surface ship, submarine, and auxiliary system signature assessments. This may include electronic, radar, acoustic, infrared, and magnetic signatures, refueling capabilities.
Other Testing Activities	
Acoustic Component Testing	Various surface vessels, moored equipment, and materials are tested to evaluate performance in the marine environment.
Chemical and Biological Simulant Testing	Chemical-biological agent simulants are deployed against surface ships.

Activity Name	Activity Description
Insertion/Extraction	Testing of submersibles capable of inserting and extracting personnel and payloads into denied areas from strategic distances.
Line Charge Testing	Surface vessels deploy line charges to test the capability to safely clear an area for expeditionary forces.
Non-Acoustic Component Testing	Tests of towed or floating buoys for communications through radio-frequencies or two-way optical communications between an aircraft and underwater system(s).
Payload Deployer Testing	Launcher systems are tested to evaluate performance.
Semi-Stationary Equipment Testing	Semi-stationary equipment (e.g., hydrophones) is deployed to determine functionality.
Towed Equipment Testing	Surface vessels or unmanned surface vehicles deploy and tow equipment to determine functionality of towed systems.

Table 15. Naval Sea System's Command proposed testing activities (Navy 2017a).

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
Anti-Submarine Warfare			
Anti-Submarine Warfare Mission Package Testing	42	210	Jacksonville RC
	4	20	Newport, RI
	4	20	NUWC Newport
	26	130	Virginia Capes RC
At-Sea Sonar Testing	2	10	Jacksonville RC Navy Cherry Point RC Northeast RC Virginia Capes RC
	1	5	Jacksonville RC Navy Cherry Point RC Virginia Capes RC
	2	10	Offshore Fort Pierce, FL Gulf of Mexico RC Jacksonville SFOMF Northeast RC Virginia Capes
	4	20	Jacksonville RC
	2	10	Navy Cherry Point RC
	8	40	NUWC Newport
	12	60	Virginia Capes RC
Pierside Sonar Testing	1	5	NSB New London NS Norfolk Port Canaveral, FL
	11	55	Bath, ME
	5	25	NSB New London
	4	20	NSB Kings Bay
	8	40	Newport, RI
	13	65	NS Norfolk
Pierside Sonar Testing (continued)	2	10	Pascagoula, MS
	3	15	Port Canaveral, FL

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
	2	10	PNS
Submarine Sonar Testing/Maintenance	16	80	Norfolk, VA
	24	120	PNS
Surface Ship Sonar Testing/Maintenance	1	5	Jacksonville RC
	1	5	NS Mayport
	3	15	NS Norfolk
	3	15	Virginia Capes RC
Torpedo (Explosive) Testing	4	20	Gulf of Mexico RC offshore Fort Pierce, FL Key West RC Navy Cherry Point RC Northeast RC Virginia Capes RC
	2	10	Gulf of Mexico RC Jacksonville RC Northeast RC Virginia Capes RC
Torpedo (Non-Explosive) Testing	7	35	Gulf of Mexico RC
	11	55	Offshore Fort Pierce, FL
	2	8	Jacksonville RC
	7	35	Navy Cherry Point RC
	8	38	Northeast RC
	30	150	NUWC Newport
	11	55	Virginia Capes RC
Countermeasure Testing	5	25	Gulf of Mexico RC Key West RC Jacksonville RC NUWC Newport Virginia Capes RC
	2–4	14	Gulf of Mexico RC Jacksonville RC Northeast RC Virginia Capes RC
Electronic Warfare			
Radar and Other System Testing	6–10	34	Gulf of Mexico RC Jacksonville RC Key West RC Navy Cherry Point RC Northeast RC NSWC Panama City NUWC Newport SFOMF Virginia Capes RC
Radar and Other System Testing	4	20	NSB New London
	0–3	3	JEB LC-FS NS Norfolk
	2	10	NS Norfolk
	2	10	Northeast RC
	21–45	129	Virginia Capes RC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
Mine Warfare			
Mine Countermeasure and Neutralization Testing	13	65	NSWC Panama City
	6	30	Virginia Capes RC
Mine Countermeasure Mission Package Testing	19	95	Gulf of Mexico RC
	10	50	Jacksonville RC
	11	55	NSWC Panama City
	2	10	SFOMF
	5	25	Virginia Capes RC
Mine Detection and Classification Testing	6	30	Gulf of Mexico RC
	10	50	Navy Cherry Point RC
	47–52	250	NSWC Panama City
	7–12	43	Riviera Beach, FL
	4	20	SFOMF
	3	15	Virginia Capes RC
Surface Warfare			
Gun Testing – Large-Caliber	12	60	Gulf of Mexico RC Jacksonville RC Key West RC Navy Cherry Point RC Northeast RC Virginia Capes RC
	1	5	Gulf of Mexico RC
	1	5	Jacksonville RC
	1	5	Key West RC
	1	5	Navy Cherry Point RC
	1	5	Northeast RC
	33	165	NSWC Panama City
	5	25	Virginia Capes RC
Gun Testing – Medium-Caliber	12	60	Gulf of Mexico RC Jacksonville RC Key West RC Navy Cherry Point RC Northeast RC Virginia Capes RC
	102	510	NSWC Panama City
	5	24	Virginia Capes RC
Gun Testing – Small-Caliber	24	120	Gulf of Mexico RC Jacksonville RC Key West RC Navy Cherry Point RC Northeast RC Virginia Capes RC
	13	65	Gulf of Mexico RC
	7	35	NSWC Panama City
	8	40	Virginia Capes RC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
Kinetic Energy Weapon Testing	61	301	Gulf of Mexico RC Jacksonville RC Key West RC Navy Cherry Point RC Northeast RC Virginia Capes RC
Missile and Rocket Testing	13	65	Gulf of Mexico RC Jacksonville RC Key West RC Navy Cherry Point RC Northeast RC Virginia Capes RC
	1	5	Gulf of Mexico RC
	2	10	Jacksonville RC
	5	25	Northeast RC
	22	110	Virginia Capes RC
Unmanned Systems			
Unmanned Aerial System Testing	15	75	Northeast RC
	17	85	NUWC Newport
	15	75	Virginia Capes RC
Unmanned Surface Vehicle System Testing	132	660	NUWC Newport
Unmanned Underwater Vehicle Testing	16	80	Gulf of Mexico RC Jacksonville RC NUWC Newport
	41	205	Gulf of Mexico RC
	25	125	Jacksonville RC
	145–146	727	NSWC Panama City
	308–309	1,541	NUWC Newport
	9	45	Riviera Beach, FL
	42	210	SFOMF
Vessel Evaluation			
Aircraft Carrier Sea Trials – Propulsion Testing	2	10	Virginia Capes RC
Large Ship Shock Trial	0-1	1	Gulf of Mexico Jacksonville RC Virginia Capes RC
In-Port Maintenance Testing	24	120	NS Mayport NS Norfolk
	2	10	NS Mayport
	5	25	NS Norfolk
Air Defense Testing	1	5	Gulf of Mexico RC
	2	10	Jacksonville RC
	1	5	Northeast RC
	5	25	Virginia Capes RC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
Propulsion Testing	34	170	Gulf of Mexico RC Jacksonville RC Key West RC Navy Cherry Point RC Northeast RC Virginia Capes RC
	86	430	Gulf of Mexico
	2	10	Jacksonville RC
	6	30	Navy Cherry Point RC
	5	25	Northeast RC
	7	35	Virginia Capes RC
Surface Warfare Testing	2	10	Gulf of Mexico RC
	13	65	Jacksonville RC
	1	5	Key West RC
	10	50	Northeast RC
	9	45	Virginia Capes RC
Undersea Warfare Testing	2	10	Jacksonville RC Virginia Capes RC
	0–2	4	Jacksonville RC Navy Cherry Point RC SFOMF Virginia Capes RC
	2	10	Gulf of Mexico RC
	6	30	Jacksonville RC
	2	10	Virginia Capes RC
Small Ship Shock Trial	0–3	3	Jacksonville RC Virginia Capes RC
Submarine Sea Trials – Propulsion Testing	1	5	Jacksonville RC
	1	5	Northeast RC
	1	5	Virginia Capes RC
Submarine Sea Trials – Weapons System Testing	2	10	Offshore Fort Pierce, FL Gulf of Mexico RC Jacksonville SFOMF Northeast Virginia Capes
	4	20	Jacksonville RC
	4	20	Northeast RC
	4	20	Virginia Capes RC
Total Ship Survivability Trials	0–1	1	Jacksonville RC Virginia Capes RC
Vessel Signature Evaluation	9	45	Jacksonville RC Virginia Capes RC
	2	10	Gulf of Mexico RC
	16	80	Jacksonville RC
	5	25	JEB LC-FS
	18	90	Virginia Capes RC

Activity Name	Annual # of Activities[1]	5-Year # of Activities	Location[2]
Hydrodynamic and Maneuverability Testing	2	10	Gulf of Mexico RC Jacksonville RC Key West RC Navy Cherry Point RC Northeast RC Virginia Capes RC
Other Testing Activities			
Insertion/Extraction	4	20	Key West RC
	264	1,320	NSWC Panama City
Line Charge Testing	4	20	NSWC Panama City
Acoustic Component Testing	33	165	SFOMF
Chemical and Biological Simulant Testing	80	400	Jacksonville RC
	80	400	Navy Cherry Point RC
	80	400	Northeast RC
	80	400	Virginia Capes RC
Non-Acoustic Component Testing	4	20	Gulf of Mexico RC
	4	20	Virginia Capes RC
Payload Deployer Testing	1	5	Gulf of Mexico RC
	1	5	Northeast RC
	39	195	NUWC Newport
Semi-Stationary Equipment Testing	4	20	Newport, RI
	11	55	NSWC Panama City
	190	950	NUWC Newport
Towed Equipment Testing	36	180	NUWC Newport
Vessel Evaluation	1	5	Jacksonville RC
	59	295	SFOMF
Unmanned Systems Activity	33	165	SFOMF

[1] For activities where the maximum number of events could vary between years, the information is presented as a "representative-maximum" number of events per year. For activities where no variation is anticipated, only the maximum number of events within a single year is provided.

[2] Locations given are areas where activities typically occur. However, activities could be conducted in other locations within the action area. Where multiple locations are provided within a single cell, the number of activities could occur in any of the locations, not in each of the locations.

Notes: JEB LC-FS: Joint Expeditionary Base Little Creek-Fort Story; Gulf of Mexico: Gulf of Mexico; Jacksonville: Jacksonville; NS: Naval Station; NSB: Naval Submarine Base; NSWC: Naval Surface Warfare Center; NUWC: Naval Undersea Warfare Center; PNS: Portsmouth Naval Shipyard; RC: Range Complex; SFOMF: South Florida Ocean Measurement Facility Testing Range; Virginia Capes: Virginia Capes

3.3.2.3 Office of Naval Research Testing Activities

As the Department of the Navy's science and technology provider, the Office of Naval Research provides technology solutions for Navy and Marine Corps needs. Testing conducted by the Office of Naval Research in the action area includes acoustic and oceanographic research, large displacement unmanned underwater vehicle (innovative naval prototype) research, and emerging mine countermeasure technology research. Table 16 describes the Office of Naval Research's testing activities while Table 17 provides a list of the proposed testing activities.

Table 16. A description of each of the Office of Naval Research's testing activities (Navy 2017a).

Activity Name	Activity Description
Acoustic and Oceanographic Science and Technology	
Acoustic and Oceanographic Research	Research using active transmissions from sources deployed from ships and unmanned underwater vehicles. Research sources can be used as proxies for current and future Navy systems.
Emerging Mine Countermeasure Technology Research	Test involves the use of broadband acoustic sources on unmanned underwater vehicles.
Large Displacement Unmanned Underwater Vehicle Testing	Autonomy testing and environmental data collection with Large Displacement Unmanned Underwater Vehicles.

Table 17. Office of Naval Research proposed testing activities (Navy 2017a).

Activity Name	Annual # of Activities	5-Year # of Activities	Location
Acoustic and Oceanographic Science and Technology			
Acoustic and Oceanographic Research	4	20	Gulf of Mexico RC
	7	35	Northeast RC
	2	10	Virginia Capes RC
Emerging Mine Countermeasure Technology Research	1	5	Jacksonville RC
	2	10	Northeast RC
	1	5	Virginia Capes RC
Large Displacement Unmanned Underwater Vehicle Testing	4	20	Gulf of Mexico RC
	12	60	Jacksonville RC
	4	20	Navy Cherry Point RC
	16	80	Northeast RC
	8	40	Virginia Capes RC

Notes: Gulf of Mexico: Gulf of Mexico; Jacksonville: Jacksonville, Florida; RC: Range Complex; Virginia Capes: Virginia Capes

3.4 Standard Operating Procedures and Mitigation Measures

Standard operating procedures have been developed by the Navy through years of experience and are implemented during Navy training and testing activities to provide for safety and mission success. This is the primary purpose of these procedures, though in many cases there are environmental benefits resulting from the implementation of standard operating procedures as well. Mitigation measures, on the other hand, are designed specifically for the purpose of avoiding or reducing environmental impacts from the proposed activities. The standard operating procedures and mitigation measures the Navy will incorporate in their training and testing activities in the action area are described below.

3.4.1 Standard Operating Procedures

When conducting training and testing activities, the Navy implements standard operating procedures to provide for safety and mission success. Navy standard operating procedures are broadcast via numerous naval instructions and manuals to ensure compliance.

3.4.1.1 Vessel Safety

The standard operating procedures for vessel safety could result in a secondary benefit to marine mammals and sea turtles through a reduction in the potential for vessel strike due to the presence of watch personnel at all times. Ships operated by or for the Navy have personnel assigned to stand watch at all times, day and night, when vessels are moving through the water (underway). Watch personnel undergo training on tasks such as avoiding hazards and ship handling. Training includes on-the-job instruction and a formal qualification program to certify that they have demonstrated all necessary skills. Skills include detection and reporting of floating or partially submerged objects. Watch personnel include officers, enlisted men and women, and civilians operating in similar capacities. Their duties as watchstanders may be performed in conjunction with other job responsibilities, such as navigating the ship or supervising other personnel. While on watch, personnel employ visual search techniques, including the use of binoculars and scanning techniques. After sunset and prior to sunrise, watch personnel employ night visual search techniques, which could include the use of night vision devices.

The primary duty of watch personnel is to ensure safety of the ship, and this includes the requirement to detect and report all objects and disturbances sighted in the water that may be indicative of a threat to the ship and its crew, such as debris, a periscope, a surfaced submarine, or a surface disturbance. Per safety requirements, watch personnel also report any marine mammals sighted that have the potential to be in the direct path of the ship as a standard collision avoidance procedure.

Navy vessels operate in accordance with the navigation rules established by the U.S. Coast Guard. All vessels operating on the water are required to follow Inland Navigation Rules (33 Code of Federal Regulations 83) and International Regulations for Preventing Collisions at Sea (72 COLREGS). Navigation rules are formalized in the Convention on the International Regulations for Preventing Collisions at Sea, 1972. Applicable navigation requirements include, but are not limited to, the presence of lookouts and the requirement that vessels proceed at a safe speed at all times so that proper and effective action can be taken to avoid collision if necessary and so they can be stopped within a distance appropriate to the prevailing circumstances and conditions.

3.4.1.2 Weapons Firing Safety

Most weapons firing activities that involve the use of explosive munitions are conducted during daylight hours. In addition, pilots of Navy aircraft are not authorized to expend ordnance, fire missiles, or drop other airborne devices through extensive cloud cover where visual clearance for non-participating aircraft and vessels in the air and on the sea surface is not possible. The two exceptions to this requirement are: (1) when operating in the open ocean, clearance for non-participating aircraft and vessels in the air and on the sea surface through radar surveillance is acceptable; and (2) when the Officer Conducting the Exercise or civilian equivalent accepts responsibility for the safeguarding of airborne and surface traffic.

During activities that involve recoverable targets (e.g., aerial drones), the Navy recovers the target and any associated decelerators/parachutes to the maximum extent practicable consistent with personnel and equipment safety. This standard operating procedure could result in a benefit to marine mammals, sea turtles, fish, and corals by reducing the potential for physical disturbance and strike, entanglement, and ingestion of applicable targets and any associated decelerators/parachutes.

3.4.1.3 Target Deployment Safety

The deployment of targets is dependent upon environmental conditions. Firing exercises involving the integrated maritime portable acoustic scoring and simulation system are typically conducted in daylight hours in Beaufort sea state[11] number 4 conditions (i.e., winds 11 to 16 knots, small waves 1 to 4 ft becoming longer, numerous whitecaps) or better to ensure safe operating conditions during buoy deployment and recovery. This standard operating procedure could result in a benefit to marine mammals and sea turtles through a reduction in the potential for physical disturbance and strike by a target.

3.4.1.4 Towed In-Water Device Safety

As a standard collision avoidance procedure, prior to deploying a towed in-water device from a manned platform, the Navy searches the intended path of the device for any floating debris, objects, or animals (e.g., driftwood, concentrations of floating vegetation, marine mammals) that have the potential to obstruct or damage the device. This standard operating procedure could result in a benefit to marine mammals and sea turtles through a reduction in the potential for physical disturbance and strike by a towed in-water device.

3.4.1.5 Pile Driving Safety

Pile driving is required during elevated causeway construction (Table 13). Due to pile driving system design and operation, the Navy performs soft starts during impact installation of each pile to ensure proper operation of the diesel impact hammer. During a soft start, an initial set of strikes from the impact hammer at reduced energy are performed before it can be operated at full power and speed. This standard operating procedure could result in a benefit to marine mammals and sea turtles because soft starts may “warn” these resources and cause them to move away from the sound source before impact pile driving increases to full operating capacity.

3.4.2 **Mitigation Measures**[12]

The Navy proposed to implement mitigation measures to avoid or reduce potential impacts from acoustic, explosive, and physical disturbance and strike stressors from training and testing

[11] http://w1.weather.gov/glossary/index.php?word=beaufort+scale
[12] We consider these mitigation measures “conservation measures”: actions that will be taken by the Navy and serve to minimize project effects on the species under review. As such, we evaluate the effects of these measures as integral parts of the proposed action to be implemented by the Navy.

activities on ESA-listed marine mammals, sea turtles, Gulf sturgeon, and coral.[13] These mitigation measures fall into two categories: procedural mitigation and mitigation areas. Procedural mitigation is mitigation that the Navy will implement whenever and wherever an applicable training or testing activity takes place within the action area. Mitigation areas are geographic locations in the action area where the Navy will implement additional measures during all or a part of the year. Additional detail on both proposed procedural mitigation and mitigation areas is provided in the sections below.

In order to ensure compliance with the proposed mitigation measures, the Navy provides environmental awareness and education to appropriate personnel (e.g., lookouts) to aid in visual observation, environmental compliance, and reporting responsibilities. Appropriate personnel (including civilian personnel) involved in mitigation and training or testing activity reporting complete one or more modules of the U.S Navy Afloat Environmental Compliance Training Series. The Afloat Environmental Compliance Training program helps Navy personnel from the most junior Sailors to Commanding Officers gain a better understanding of their personal environmental compliance roles and responsibilities. It helps to ensure Navy-wide compliance with environmental requirements. Modules include the following:

- Introduction to the U.S. Navy Afloat Environmental Compliance Training Series. The introductory module provides information on environmental laws (e.g., ESA, MMPA) and the corresponding responsibilities that are relevant to Navy training and testing activities. The material explains why environmental compliance is important in supporting the Navy's commitment to environmental stewardship.
- Marine Species Awareness Training. All bridge watch personnel, Commanding Officers, Executive Officers, maritime patrol aircraft aircrews, anti-submarine warfare and mine warfare rotary-wing aircrews, Lookouts, and equivalent civilian personnel must successfully complete the Marine Species Awareness Training prior to standing watch or serving as a Lookout. The Marine Species Awareness Training provides information on sighting cues, visual observation tools and techniques, and sighting notification procedures. Navy biologists developed Marine Species Awareness Training to improve the effectiveness of visual observations for biological resources, focusing on marine mammals and sea turtles, and including floating vegetation, jellyfish aggregations, and flocks of seabirds. The most recent Marine Species Awareness Training was released in 2014 and approved by NMFS (Navy 2017a).
- U.S. Navy Protective Measures Assessment Protocol. This module provides the necessary instruction for accessing mitigation requirements during the training and testing activity planning phase using the Protective Measures Assessment Protocol software tool.

[13] Note that the Navy did not propose mitigation for ESA-listed fish species other than Gulf sturgeon.

- U.S. Navy Sonar Positional Reporting System and Marine Mammal Incident Reporting. This module provides instruction on the procedures and activity reporting requirements for the Sonar Positional Reporting System and marine mammal incident reporting.

According to the Navy's BA, Navy scientists and planners have observed enhanced knowledge and understanding about the Navy's environmental compliance responsibilities among Lookouts and members of the operational community since the development of the U.S. Navy Afloat Environmental Compliance Training Series (Navy 2017a). As an example, since the Navy implemented the original Marine Species Awareness Training in 2007, the average rate of Navy vessel strikes of large whales has decreased by three times when compared with the prior 10-year period (1997-2006). It is likely that the implementation of the Marine Species Awareness Training starting in 2007, and the additional U.S. Navy Afloat Environmental Compliance Training Series modules starting in 2014, has contributed to this reduction in strikes. This indicates that the environmental awareness and education program is helping to improve the effectiveness of mitigation implementation.

The following sections summarize the mitigation measures that the Navy proposes to implement in association with the training and testing activities analyzed in this document. A complete discussion of the mitigation measures, as well as measures considered by the Navy but not proposed, and the evaluation process used by the Navy to develop, assess, and select mitigation measures, can be found in Chapter 5 (Mitigation) of the AFTT DEIS/OEIS (Navy 2017c). For each of the mitigation measures described below, the Navy operational community provided input on the practicability of each measure and whether additional mitigation could be implemented to further reduce potential impacts to ESA-listed species.

3.4.2.1 Procedural Mitigation

Procedural mitigation generally involves: (1) the use of one or more trained Lookouts to observe for specific biological resources within a mitigation zone[14]; (2) requirements for Lookouts to immediately communicate sightings of specific biological resources to the appropriate watch station for information dissemination; and (3) requirements for the watch station to implement mitigation (e.g., halt an activity) until certain recommencement conditions have been met.

Lookouts are personnel who perform similar duties as the standard watch personnel described previously, such as observing for objects that could present a potential danger to the observation platform (e.g., debris in the water, incoming vessels, and incoming aircraft). Lookouts have an additional duty of helping meet the Navy's mitigation requirements by visually observing mitigation zones for marine mammals and sea turtles. However, for some activities, Lookouts

[14] Mitigation zones are areas at the surface of the water (measured as the radius from a stressor) within which training or testing activities would be halted, powered down, or modified to protect specific biological resources from an injurious impact (e.g., Permanent Threshold Shift [PTS], vessel strike).

may also be required to observe for additional biological resources, such as birds, fish, jellyfish aggregations, or floating vegetation. In this consultation, the term "floating vegetation" refers specifically to floating concentrations of detached kelp paddies and *Sargassum*. Some biological resources can be indicators of potential marine mammal or sea turtle presence because animals have been known to seek shelter in, feed on, or feed in them. For example, young sea turtles have been known to hide from predators and eat the algae associated with floating concentrations of *Sargassum*. The Navy proposes to observe for these additional biological resources during certain activities to protect ESA-listed species or to offer an additional layer of protection for marine mammals and sea turtles.

Depending on the activity, a Lookout may be positioned on a ship (i.e., surface ships and surfaced submarines), on a small boat (e.g., a rigid-hull inflatable boat), in an aircraft, on a pier, or on the shore. Certain platforms, such as aircraft and small boats, have manning or space restrictions; therefore, the Lookout on these platforms is typically an existing member of the aircraft or boat crew (e.g., pilot) who is responsible for other essential tasks (e.g., navigation). On platforms that do not have manning and space restrictions (such as large ships), the Officer of the Deck, a member of the bridge watch team, or other personnel may be designated as the Lookout. The Navy is unable to position Lookouts on unmanned vehicles and unmanned aerial systems, or have Lookouts observe during activities that use systems deployed from or towed by unmanned platforms.

The Navy's passive acoustic devices (e.g., remote acoustic sensors, expendable sonobuoys, passive acoustic sensors on submarines) can complement visual observations when passive acoustic assets are already participating in an activity. When in use, the passive acoustic assets can detect vocalizing marine mammals within the frequency bands already being monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot be used to determine an animal's location or confirm its presence in a mitigation zone. Marine mammal detections made with the use of passive acoustic devices will be communicated to Lookouts to alert them of possible marine mammal presence in the vicinity. Lookouts will use any information on possible presence of animals from passive acoustic monitoring to assist in their visual observations of the mitigation zone.

The Navy takes several courses of action in response to a sighting of an applicable biological resource (e.g., ESA-listed species, floating *Sargassum*) in a mitigation zone. First, a Lookout will communicate the sighting to the appropriate watch station. Next, the watch station will implement the prescribed mitigation (e.g., powering down sonar, halting an explosion, maneuvering a vessel). If floating vegetation is observed prior to the initial start of an activity, the activity will either be relocated to an area where floating vegetation is not observed, or the initial start of the activity will be halted until the mitigation zone is clear of floating vegetation (the Navy does not propose to halt activities if vegetation floats into the mitigation zone after activities commence as the Navy determined such an action not to be practicable for operational and safety reasons). For sightings of marine mammals and sea turtles during an activity, the activity will be suspended or otherwise altered based on the applicable mitigation measures until one of the five recommencement conditions listed below has been met. The recommencement conditions are designed to allow a sighted animal to leave the mitigation zone before an activity or the use of a stressor resumes.

1) The animal is observed exiting the mitigation zone;
2) The animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the stressor source;
3) The mitigation zone has been clear of any additional sightings for a specific wait period;
4) For mobile activities, the stressor source has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting; or
5) For activities using hull-mounted sonar, the ship concludes that dolphins are deliberately closing in on the ship to ride the ship's bow wave, and are therefore out of the main transmission axis of the sonar (and there are no other marine mammal or sea turtle sightings within the mitigation zone).

In some instances, such as if an animal dives underwater after a sighting, it may not be possible for a Lookout to visually verify if that animal has left the mitigation zone. To account for this, one of the recommencement conditions is an established post-sighting wait period. Wait periods are designed to allow animals time to resurface and be available to be sighted again before an activity or the use of a stressor resumes. The Navy proposes a 30 minute wait period to activities conducted from vessels and activities that involve aircraft that are not typically fuel constrained (e.g., maritime patrol aircraft) because 30 minutes is the maximum amount of time that those activities can be halted without preventing the activity from meeting its intended objective (Navy 2017a). A 30 minute period covers the average dive times of most marine mammals, and a portion of the dive times of sea turtles and deep-diving marine mammals (i.e., sperm whales, dwarf and pygmy sperm whales [*Kogia* species], and beaked whales). The Navy proposes a shorter wait period of 10 minute for activities that involve aircraft with fuel constraints (e.g., rotary-wing aircraft [i.e., helicopters], fighter aircraft) because 10 minutes is the maximum amount of time that those activities can be halted without compromising safety due to aircraft fuel restrictions (Navy 2017a). A 10 minute period covers a portion of the marine mammal and sea turtle dive times, but not the average dive times of all species.

The procedural mitigation measures described below are organized by stressor type and activity category. For sonar and explosive sources, proposed mitigation is dependent on the sonar source and the net explosive weight of the detonation. Sonar sources are classified into "bins" as listed in Table 18, and as explained in more detail in Section 6.1.3. Explosives were classified into bins based on net explosive weight as described in Table 19, and as explained in more detail in Section 6.2. In general, the Navy's mitigation aims to reduce the potential for injury of ESA-listed marine mammals and sea turtles to occur. Additionally, implementing the mitigation could help avoid or reduce the potential for exposure to higher levels of sound that may result in less severe effects (e.g., TTS). [15]

In order to better organize and facilitate the analysis of approximately 300 individual sources of underwater sound deliberately employed by the Navy including sonars, other transducers (devices that convert energy from one form to another—in this case, to sound waves), air guns, and explosives, the Navy developed a series of source classifications, or source bins. The source classification bins do not include the broadband sounds produced incidental to pile driving; vessel and aircraft transits; and weapons firing.

Table 18. Sonar sources used in the action area and their bin classification (Navy 2017a).

Source Class Category	Bin	Description
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF3	LF sources greater than 200 dB
	LF4	LF sources equal to 180 dB and up to 200 dB
	LF5	LF sources less than 180 dB
	LF6	LF sources greater than 200 dB with long pulse lengths
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-61)
	MF1K	Kingfisher mode associated with MF1 sonars
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22)
	MF5	Active acoustic sonobuoys (e.g., DICASS)
	MF6	Active underwater sound signal devices (e.g., MK 84)
	MF8	Active sources (greater than 200 dB) not otherwise binned
	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz (continued)	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%
	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%
	MF14	Oceanographic MF sonar

[15] That is, the mitigation zone typically covers much of the range to auditory injury, but implementing the mitigation could also reduce the potential for exposures that could result in TTS, particularly more severe instances of TTS.

Source Class Category	Bin	Description
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)
	HF3	Other hull-mounted submarine sonars (classified)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	HF5	Active sources (greater than 200 dB) not otherwise binned
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned
	HF7	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned
	HF8	Hull-mounted surface ship sonars (e.g., AN/SQS-61)
Very High Frequency Sonars (VHF): Non-tactical sources that produce signals between 100 and 200 kHz	VHF1	Very high frequency sources greater than 200 dB
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	MF systems operating above 200 dB
	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK 3)
	ASW5[3]	MF sonobuoys with high duty cycles
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK-46, MK-54, or Anti-Torpedo Torpedo)
	TORP2	Heavyweight torpedo (e.g., MK-48)
	TORP 3	Heavyweight torpedo (e.g., MK 48)
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	HF sources with short pulse lengths, narrow beam widths, and focused beam patterns
Acoustic Modems (M): Systems used to transmit data through the water	M3	MF acoustic modems (greater than 190 dB)
Swimmer Detection Sonars (SD): Systems used to detect divers and submerged *swimmers*	SD1 –SD2	HF and VHF sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	MF SAS systems
	SAS2	HF SAS systems
	SAS3	VHF SAS systems
	SAS4	MF to HF broadband mine countermeasure sonar
Broadband Sound Sources (BB):	BB1	MF to HF mine countermeasure sonar

Source Class Category	Bin	Description
Sonar systems with large frequency spectra, used for various purposes	BB2	HF to VHF mine countermeasure sonar
	BB4	LF to MF oceanographic source
Broadband Sound Sources (BB) (continued): Sonar systems with large frequency spectra, used for various purposes	BB5	LF to MF oceanographic source
	BB6	HF oceanographic source
	BB7	LF oceanographic source

Table 19. Explosive bins proposed for use in the action area.

Bin	Net Explosive Weight[1] (lb.)	Example Explosive Source
E1	0.1–0.25	Medium-caliber projectile
E2	> 0.25–0.5	Medium-caliber projectile
E3	> 0.5–2.5	Large-caliber projectile
E4	> 2.5–5	Mine neutralization charge
E5	> 5–10	5 inch projectile
E6	> 10–20	Hellfire missile
E7	> 20–60	Demo block/ shaped charge
E8	> 60–100	Lightweight torpedo
E9	> 100–250	500 lb. bomb
E10	> 250–500	Harpoon missile
E11	> 500–650	650 lb. mine
E12	> 650–1,000	2,000 lb. bomb
E16	> 7,250–14,500	Littoral Combat Ship full ship shock trial
E17	> 14,500–58,000	Aircraft carrier full ship shock trial

[1] Net Explosive Weight refers to the equivalent amount of trinitrotoluene the actual weight of a munition may be larger due to other components.

**lb. = pounds*

3.4.2.1.1 Active Sonar

As described in Table 20, the Navy proposes to implement procedural mitigation to avoid the potential for marine mammals and sea turtles to be exposed to levels of sound that could result in injury (i.e., PTS) from active sonar to the maximum extent practicable.

Table 20. Procedural mitigation for active sonar (Navy 2018a).

Procedural Mitigation Description

Stressor or Activity
• Low-frequency active sonar, mid-frequency active sonar, high-frequency active sonar
  o For vessel-based activities, mitigation applies only to sources that are positively controlled and deployed from manned surface vessels (e.g., sonar sources towed from manned surface platforms).
  o For aircraft-based activities, mitigation applies only to sources that are positively controlled and deployed from manned aircraft that do not operate at high altitudes (e.g., rotary-wing aircraft). Mitigation does not apply to active sonar sources deployed from unmanned aircraft or aircraft operating at high altitudes (e.g., maritime patrol aircraft).

Resource Protection Focus • Marine mammals • Sea turtles (only for sources <2 kilohertz [kHz])

Number of Lookouts and Observation Platform
• Hull-mounted sources:
  o 1 Lookout: Platforms with space or manning restrictions while underway (at the forward part of a small boat or ship) and platforms using active sonar while moored or at anchor (including pierside)
  o 2 Lookouts: Platforms without space or manning restrictions while underway (at the forward part of the ship)
  o 4 Lookouts: Pierside sonar testing activities at Port Canaveral, Florida and Kings Bay, Georgia
• Sources that are not hull-mounted:
  o 1 Lookout on the ship or aircraft conducting the activity

Mitigation Requirements
• Mitigation zones:
  o 1,000 yard power down, 500 yard power down, and 200 yard shut down for low-frequency active sonar ≥200 decibels (dB) and hull-mounted mid-frequency active sonar
  o 200 yard shut down for low-frequency active sonar <200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar
• Prior to the initial start of the activity (e.g., when maneuvering on station):
  o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear.
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of active sonar transmission.
• During the activity:
  o Low-frequency active sonar ≥200 decibels (dB) and hull-mounted mid-frequency active sonar: Observe the mitigation zone for marine mammals and sea turtles (for sources <2 kHz); power down active sonar transmission by 6 dB if observed within 1,000 yard of the sonar source; power down an additional 4 dB (10 dB total) within 500 yards; cease transmission within 200 yards.
  o Low-frequency active sonar <200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar: Observe the mitigation zone for marine mammals and sea turtles (for sources <2 kHz); cease active sonar transmission if observed within 200 yards of the sonar source.
• Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity:
  o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing or powering up active sonar transmission) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the sonar source; (3) the mitigation zone has been clear from any additional sightings for 10 minutes for aircraft-deployed sonar sources or 30 minutes for vessel-deployed sonar sources; (4) for mobile activities, the active sonar source has transited a distance equal to double that of the mitigation zone size beyond the

Procedural Mitigation Description
location of the last sighting; or (5) for activities using hull-mounted sonar, the ship concludes that dolphins are deliberately closing in on the ship to ride the ship's bow wave, and are therefore out of the main transmission axis of the sonar (and there are no other marine mammal sightings within the mitigation zone). • Additional requirements: o At Port Canaveral, Florida and Kings Bay, Georgia the Navy will equip Lookouts with polarized sunglasses and conduct active sonar activities during daylight hours to ensure adequate sightability of sea turtles. The Navy will notify the Port Authority prior to commencing pierside sonar testing at these locations. The Navy will observe the mitigation zone for marine mammals and sea turtles for 30 minutes after completion of pierside sonar testing at these locations. o The Navy will reduce mid-frequency active sonar transmissions at Kings Bay, Georgia by at least 36 dB from full power. The Navy will communicate sightings of sea turtles (e.g., time, location, count, animal size, description of research tags if present, direction of travel) made during or after pierside sonar testing at Kings Bay, Georgia to the Georgia Department of Natural Resources sightings hotline, Base Natural Resources Manager, and Port Operations. Port Operations will disseminate sightings information to other vessels operating in the vicinity.

For low-frequency active sonar at 200 dB or more and hull-mounted mid-frequency active sonar, sources in bin mid frequency 1 (MF1; Table 18) have the longest predicted ranges to PTS. For sources within bin MF1, the 1,000 yard and 500 yard power down mitigation zones extend beyond the average ranges to PTS for all functional hearing groups.[16] The 200 yard shut down mitigation zone for bin MF1 extends beyond the average range to PTS for all hearing groups with ESA-listed species. The impact ranges for the 200 yard shut down mitigation zone were calculated based on full power transmissions and do not consider that the impact ranges will be reduced if one or both of the power down mitigations is implemented as required. The mitigation will be even more protective for low-frequency active sonar at 200 dB or more and hull-mounted mid-frequency active sonar sources used at lower source levels with shorter impact ranges.

For low-frequency active sonar below 200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar, sources in bin high-frequency 4 (HF4; Table 19) have the longest predicted ranges to PTS. For sources within bin HF4, the 200 yard. shut down mitigation zone extends beyond the average range to PTS for all functional hearing groups. The mitigation will be even more protective for low-frequency active sonar below 200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar sources that fall within lower source bins with shorter impact ranges.

[16] Functional hearing groups were defined by NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals NOAA. 2018. 2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0)..

3.4.2.1.2 Air Guns

Table 20 describes the procedural mitigation proposed for the use of air guns. The mitigation zone extends beyond the average range to PTS for all functional hearing groups, when assuming 100 air gun pulses (i.e., the maximum number of pulses used during an exercise). The mitigation will be even more protective for air gun activities that use less than 100 pulses, because these activities have even shorter impact ranges. The small mitigation zone size and proximity to the observation platform will help increase the likelihood that Lookouts will detect marine mammals and sea turtles in the area where the use of air guns is planned or occurring.

Table 20. Procedural mitigation for air guns (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Air guns
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on a ship or pierside
Mitigation Requirements • Mitigation zone: o 150 yards around the air gun • Prior to the initial start of the activity (e.g., when maneuvering on station): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of air gun use. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease air gun use. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing air gun use) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the air gun; (3) the mitigation zone has been clear from any additional sightings for 30 minutes; or (4) for mobile activities, the air gun has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

3.4.2.1.3 Pile Driving

Table 21 describes the proposed procedural mitigation for pile driving. The ranges to effect from impact pile driving are longer than the ranges to effect for vibratory pile extraction. For impact pile driving, the mitigation zone extends beyond the maximum ranges to PTS for all functional hearing groups. The mitigation will be even more protective for vibratory pile extraction, since it has shorter impact ranges. The small mitigation zone size and proximity to the observation platform will help increase the likelihood that Lookouts will detect marine mammals and sea turtles in the area.

Table 21. Procedural mitigation for pile driving (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Pile driving and pile extraction sound during Elevated Causeway System training
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the shore, the elevated causeway, or a small boat
Mitigation Requirements • Mitigation zone: o 100 yards around the pile • Prior to the initial start of the activity (for 30 minutes): o Observe the mitigation zone for floating vegetation; if observed, delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, delay the start of pile driving or vibratory pile extraction. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease impact pile driving or vibratory pile extraction. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing pile driving or pile extraction) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the pile driving location; or (3) the mitigation zone has been clear from any additional sightings for 30 minutes.

3.4.2.1.4 Weapons Firing Noise

Table 22 describes the proposed procedural mitigation measures for weapons firing noise. The mitigation zone extends beyond the distance to which marine mammals and sea turtles will be expected to experience PTS from weapons firing noise. The small mitigation zone size and proximity to the observation platform will help increase the likelihood that Lookouts will detect marine mammals and sea turtles in the area where weapons will be or are being fired.

Table 22. Procedural mitigation for weapons firing noise (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Weapons firing noise associated with large-caliber gunnery activities
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the ship conducting the firing • Depending on the activity, the Lookout could be the same one described for Explosive Medium-Caliber and Large-Caliber Projectiles or Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions.
Mitigation Requirements • Mitigation zone: o 30° on either side of the firing line out to 70 yards from the muzzle of the weapon being fired • Prior to the initial start of the activity: o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of weapons firing. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease weapons firing. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing weapons firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the firing ship; (3) the mitigation zone has been clear from any additional sightings for 30 minutes; or (4) for mobile activities, the firing ship has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

3.4.2.1.5 Explosive Sonobuoys

Table 23 describes the proposed procedural mitigation for the use of explosive sonobuoys.

Table 23. Procedural mitigation for explosive sonobuoys (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Explosive sonobuoys
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft or on small boat • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: o 600 yards around an explosive sonobuoy • Prior to the initial start of the activity (e.g., during deployment of a sonobuoy field, which typically lasts 20–30 minutes.): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations. o Visually observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of sonobuoy or source/receiver pair detonations. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease sonobuoy or source/receiver pair detonations. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the sonobuoy; or (3) the mitigation zone has been clear from any additional sightings for 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained. • After completion of the activity (e.g., prior to maneuvering off station): o When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals and sea turtles in the vicinity of where detonations occurred; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures. o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Explosive sonobuoys in bin E4 (e.g., Improved Extended Echo Ranging Sonobuoys) have longer impact ranges than other explosive sonobuoys used in the action area. For bin E4, the mitigation zone extends beyond the average ranges to PTS for all functional hearing groups with ESA-listed species except low-frequency cetaceans. The mitigation will be more protective for explosive sonobuoys in bin E1 or bin E3 (e.g., MK-61 SUS) with shorter impact ranges.

Some activities that use explosive sonobuoys involve detonations of a single sonobuoy or sonobuoy pair, while other activities involve deployment of a field of sonobuoys that may be dispersed over a large distance. Lookouts will have a better likelihood of detecting marine mammals and sea turtles when observing the mitigation zone around a single sonobuoy, sonobuoy pair, or a smaller sonobuoy field than when observing a sonobuoy field dispersed over a large distance. When observing large sonobuoy fields, Lookouts will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.6 Explosive Torpedoes

Table 24 describes the proposed procedural mitigation for the use of explosive torpedoes.

Table 24. Procedural mitigation for explosive torpedoes (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Explosive torpedoes
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: o 2,100 yards around the intended impact location • Prior to the initial start of the activity (e.g., during deployment of the target): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations. o Visually observe the mitigation zone for marine mammals, sea turtles, and jellyfish aggregations; if observed, relocate or delay the start of firing. • During the activity: o Observe the mitigation zone for marine mammals, sea turtles, and jellyfish aggregations; if observed, cease firing. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; or (3) the mitigation zone has been clear from any additional sightings for 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained. • After completion of the activity (e.g., prior to maneuvering off station): o When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals and sea turtles in the vicinity of where detonations occurred; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures. o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Bin E11 has the longest impact ranges for explosive torpedoes used in the action area. For bin E11, the mitigation zone extends beyond the average ranges to PTS for all functional hearing groups except high-frequency cetaceans (which are not ESA-listed in the action area), low-frequency cetaceans, and phocids (which are not ESA-listed in the action area). The mitigation will be more protective for explosive torpedoes in lower bins (e.g., bin E8) with shorter impact ranges.

Explosive torpedo activities involve detonations at a target that is located down range of the firing platform. Due to the distance between the mitigation zone and the observation platform, Lookouts will have a better likelihood of detecting large visual cues (e.g., whale blows or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles. Some species of sea turtles forage on jellyfish, and some of the locations where explosive torpedo activities could occur support high densities of jellyfish during part of the year. Observing for indicators of marine mammal and sea turtle presence (including jellyfish aggregations) will further help avoid or reduce impacts on these resources within the mitigation zone. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.7 Explosive Medium-Caliber and Large-Caliber Projectiles

Table 25 describes the proposed procedural mitigation measures for the use of explosive medium-caliber and large-caliber projectiles.

Table 25. Procedural mitigation for explosive medium-caliber and large-caliber projectiles (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using explosive medium-caliber and large-caliber projectiles   o Mitigation applies to activities using a surface target
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout on the vessel or aircraft conducting the activity   o For activities using explosive large-caliber projectiles, depending on the activity, the Lookout could be the same as the one described for Weapons Firing Noise. • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.

Mitigation Requirements
• Mitigation zones:
  o 200 yards around the intended impact location for air-to-surface activities using explosive medium-caliber projectiles
  o 600 yards around the intended impact location for surface-to-surface activities using explosive medium-caliber projectiles
  o 1,000 yards around the intended impact location for surface-to-surface activities using explosive large-caliber projectiles
• Prior to the initial start of the activity (e.g., when maneuvering on station):
  o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear.
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of firing.
• During the activity:
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease firing.
• Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity:
  o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; (3) the mitigation zone has been clear from any additional sightings for 10 minutes for aircraft-based firing or 30 minutes for vessel-based firing; or (4) for activities using mobile targets, the intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.
• After completion of the activity (e.g., prior to maneuvering off station):
  o When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals and sea turtles in the vicinity of where detonations occurred; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures.
  o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Of the activities that will implement the 1,000 yard mitigation zone, explosive large-caliber projectiles in bin E5 (e.g., 5 inch projectiles) have the longest impact ranges. For bin E5, the 1,000 yard mitigation zone extends beyond the average ranges to PTS for all functional hearing groups with ESA-listed species. Of the activities that will implement the 600 yard or 200 yard mitigation zones, explosive medium-caliber projectiles in bin E2 (e.g., 40-millimeter projectiles) have the longest impact ranges. For bin E2, both the 600 yard mitigation zone and 200 yard mitigation zone extend beyond the average ranges to PTS for all functional hearing groups with ESA-listed species. The mitigation zones will be even more protective during the use of the smaller explosive projectiles (e.g., bin E1) with shorter impact ranges.

Large-caliber gunnery activities involve the firing of projectiles at a target located up to 6 NM down range from the firing ship. Medium-caliber gunnery activities involve vessels or aircraft firing projectiles at targets that may be located up to 4,000 yards. from the firing platform, although typically the targets for these activities are much closer. Lookouts will have a better likelihood of detecting marine mammals and sea turtles when observing mitigation zones around targets that are located close to the firing platform. When observing activities that use a target located far from the firing platform, Lookouts will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles. When aircraft are firing, Lookouts will have a better vantage point for observing the mitigation zone, particularly when the target is located far from the firing platform because the lookout will be stationed with a better view of the mitigation zone. Observing for indicators of marine mammal and sea turtle presence will further help avoid or reduce impacts on these resources within the mitigation zone, particularly when observing from aircraft and when the target is located close to the firing platform. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.8 Explosive Missiles and Rockets

Table 26 describes the proposed procedural mitigation for the use of explosive missiles and rockets.

Table 26. Procedural mitigation for explosive missiles and rockets (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Aircraft-deployed explosive missiles and rockets   o Mitigation applies to activities using a surface target
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.

Mitigation Requirements
• Mitigation zones:
  o 900 yards around the intended impact location for missiles or rockets with 0.6–20 pound net explosive weight
  o 2,000 yards around the intended impact location for missiles with 21–500 pound net explosive weight
• Prior to the initial start of the activity (e.g., during a fly-over of the mitigation zone):
  o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear.
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of firing.
• During the activity:
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease firing.
• Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity:
  o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; or (3) the mitigation zone has been clear from any additional sightings for 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained.
• After completion of the activity (e.g., prior to maneuvering off station):
  o When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals and sea turtles in the vicinity of where detonations occurred; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures.
  o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

For explosive missiles with 21 to 500 pound net explosive weight, missiles in bin E10 (e.g., Harpoon missiles) have the longest impact ranges. For bin E10, the 2,000 yard mitigation zone extends beyond the average ranges to PTS for all functional hearing groups with ESA-listed species. The mitigation will be even more protective for smaller explosive projectiles with shorter impact ranges (e.g., missiles in bin E9). For explosive missiles and rockets with 0.6 to 20 pound net explosive weight, missiles in bin E6 (e.g., Hellfire missiles) have the longest impact ranges. For bin E6, the 900 yard mitigation zone extends beyond the average ranges to PTS for all functional hearing groups with ESA-listed species. The mitigation will be even more protective during the use of smaller explosive projectiles with shorter impact ranges (e.g., rockets in bin E3).

Missile and rocket exercises involve a ship or aircraft firing munitions at a target that is typically located up to 15 NM away, and infrequently up to 75 NM away from the firing platform. The mitigation only applies to aircraft-deployed missiles and rockets because aircraft can fly over the intended impact area prior to firing a missile. Observation of the mitigation zone is not possible when missiles and rockets are fired from a ship due to the distance between the firing ship and the intended impact location. Even when aircraft are firing, there is a chance that animals could enter the mitigation zone after the aircraft conducts its close-range mitigation zone observations and before firing begins (once the aircraft has transited to its firing position). Due to the distance between the mitigation zone and the observation platform, Lookouts will have a better likelihood of detecting marine mammals and sea turtles during the close-range observations, and are less likely to detect these resources once positioned at the firing location, particularly individual marine mammals, cryptic marine mammal species, and sea turtles. Observing for indicators of marine mammal and sea turtle presence (e.g., presence of jellyfish or *Sargassum*) will further help avoid or reduce impacts on these resources within the mitigation zone. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.9 Explosive Bombs

Table 27 describes the proposed procedural mitigation for the use of explosive bombs.

Table 27. Procedural mitigation for explosive bombs (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Explosive bombs
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in the aircraft conducting the activity • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: o 2,500 yard around the intended target • Prior to the initial start of the activity (e.g., when arriving on station): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of bomb deployment. • During the activity (e.g., during target approach): o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease bomb deployment. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing bomb deployment) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target; (3) the mitigation zone has been clear from any additional sightings for 10 minutes.; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting. • After completion of the activity (e.g., prior to maneuvering off station): o When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals and sea turtles in the vicinity of where detonations occurred; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures. o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Explosive bombs in bin E12 (e.g., 2,000- pound bombs) have the longest impact ranges of any bomb used in the action area. For bin E12, the 2,500 yard mitigation zone extends beyond the average ranges to PTS for all functional hearing groups with ESA-listed species. The mitigation will be more protective during the use of smaller bombs with shorter impact ranges (e.g., 250 pound bombs, 500 pound bombs).

Bombing exercises involve a participating aircraft deploying munitions at a surface target located beneath the firing platform. During target approach, aircraft maintain a relatively steady altitude of approximately 1,500 ft, and Lookouts will, by necessity for safety and mission success, primarily focus their attention on the water surface below and surrounding the location of bomb deployment. The Lookout's vantage point will serve as an advantage for observing marine mammals and sea turtles within this area. Lookouts will have a better likelihood of detecting individual marine mammals and sea turtles that are in the central portion of the mitigation zone (around the target location where Lookout attention will be focused) and will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles near the perimeter of the mitigation zone. Observing for indicators of marine mammal and sea turtle presence will further help avoid or reduce impacts on these resources within the mitigation zone. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.10 Sinking Exercises

Table 28 describes the proposed procedural mitigation during sinking exercises.

Table 28. Procedural mitigation for sinking exercises (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Sinking exercises
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 2 Lookouts (one positioned in an aircraft and one on a vessel) • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: o 2.5 NM around the target ship hulk • Prior to the initial start of the activity (90 minutes prior to the first firing): o Conduct aerial observations of the mitigation zone for floating vegetation; delay the start until the mitigation zone is clear. o Conduct aerial observations of the mitigation zone for marine mammals, sea turtles, and jellyfish aggregations; if observed, delay the start of firing. • During the activity: o Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations. o Visually observe the mitigation zone for marine mammals and sea turtles from the vessel; if observed, cease firing. o Immediately after any planned or unplanned breaks in weapons firing of longer than 2 hours, observe the mitigation zone for marine mammals and sea turtles from the aircraft and vessel; if observed, delay recommencement of firing. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the target ship hulk; or (3) the mitigation zone has been clear from any additional sightings for 30 minutes. • After completion of the activity (for 2 hours after sinking the vessel or until sunset, whichever comes first): o Observe for marine mammals and sea turtles in the vicinity of where detonations occurred; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures. o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Bin E12 has the longest impact ranges for the types of explosives used during a sinking exercise in the action area. For bin E12, the mitigation zone extends beyond the average ranges to PTS for all functional hearing groups with ESA-listed species. The mitigation will be more protective for explosives in lower bins with shorter impact ranges used during a sinking exercise (e.g., bin E5 and bin E10).

A sinking exercise is a specialized training exercise that provides an opportunity for ship, submarine, and aircraft crews to use multiple weapons systems to deliver explosive ordnance to deliberately sink a deactivated vessel. The exercise occurs only in daylight hours and typically lasts from four to eight hours over the course of one to two days. Because the activity is scheduled to ensure that it is conducted only in daylight hours, it is unlikely that the 2-hour post-activity observation period will be shortened due to nightfall. Therefore, the Navy expects to be able to complete the full 2-hour post-activity observation period during each sinking exercise. There is a chance that animals could enter the mitigation zone after the aircraft conducts its close-range mitigation zone observations and before firing begins (once the aircraft has transited to its distant firing position). The Lookout positioned on the vessel will have a better likelihood of detecting individual marine mammals and sea turtles that are in the central portion of the mitigation zone (near the target ship hulk). Near the perimeter of the mitigation zone, the Lookout will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles. The Lookout positioned in an aircraft will be able to assist the vessel-based Lookout by observing the entire mitigation zone, including near the perimeter, because the aircraft will be able to transit a larger area more quickly (e.g., during range clearance), and will offer a better vantage point. Some species of sea turtles forage on jellyfish in the region where this activity occurs. Observing for indicators of marine mammal and sea turtle presence, like aggregations of jellyfish, will help avoid or reduce impacts on these resources within the mitigation zone. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.11 Explosive Mine Countermeasure and Neutralization Activities

Table 29 describes the proposed procedural mitigation when conducting explosive mine countermeasure and neutralization activities.

Table 29. Procedural mitigation for explosive mine countermeasure and neutralization activities (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Explosive mine countermeasure and neutralization activities
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on a vessel or in an aircraft when implementing the smaller mitigation zone • 2 Lookouts (one positioned in an aircraft and one on a small boat) when implementing the larger mitigation zone • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zones: o 600 yards around the detonation site for activities using 0.1–5 pound net explosive weight o 2,100 yards around the detonation site for activities using 6–650 pound net explosive weight (including high explosive target mines) • Prior to the initial start of the activity (e.g., when maneuvering on station; typically, 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of detonations. • During the activity: o Observe for marine mammals and sea turtles; if observed, cease detonations. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to detonation site; or (3) the mitigation zone has been clear from any additional sightings for 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained. • After completion of the activity (typically 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained): o Observe for marine mammals and sea turtles in the vicinity of where detonations occurred; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures. o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

For activities using 6 to 650 pound net explosive weight, charges in bin E11 (e.g., 650 pound high explosive target mines) have the longest impact ranges. For bin E11, the 2,100 yard mitigation zone extends beyond the average ranges to PTS for all functional hearing groups with ESA-listed species except low-frequency cetaceans. For activities using 0.1 to 5 pound net explosive weight, charges in bin E4 (e.g., 5 pound net explosive weight charges) have the longest impact ranges. For bin E4, the 600 yard mitigation zone extends beyond the average ranges to PTS for all functional hearing groups with ESA-listed species except low-frequency cetaceans. The mitigation zones will be more protective during the use of smaller explosive charges (e.g., bin E2) with shorter impact ranges.

The types of charges used in these activities are positively controlled, which means the detonation is controlled by the personnel conducting the activity and is not authorized until the area is clear at the time of detonation. Due to their lower vantage point, Lookouts on small boats will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) or splashes of individual marine mammals than cryptic marine mammal species and sea turtles near the mitigation zone perimeter. The use of an aircraft in addition to a vessel to observe a larger mitigation zone will help increase the chance that marine mammals and sea turtles will be observed. Observing for indicators of marine mammal and sea turtle presence will help avoid or reduce impacts on these resources within the mitigation zones. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.12 Explosive Mine Neutralization Activities Involving Navy Divers

Table 30 describes the proposed procedural mitigation for explosive mine neutralization activities involving Navy divers. The types of charges used during explosive mine neutralization activities involving Navy divers are either positively controlled (i.e., the detonation is controlled by the personnel conducting the activity and is not authorized until the area is clear at the time of detonation), or initiated using a time-delay fuse (i.e., the detonation is fused with a specified time-delay by the personnel conducting the activity and is not authorized until the area is clear at the time the fuse is initiated, but cannot be terminated once the fuse is initiated due to human safety concerns).

Table 30. Procedural mitigation for explosive mine neutralization activities involving Navy divers (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Explosive mine neutralization activities involving Navy divers
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 2 Lookouts (two small boats with one Lookout each, or one Lookout on a small boat and one in a rotary-wing aircraft) when implementing the smaller mitigation zone • 4 Lookouts (two small boats with two Lookouts each), and a pilot or member of an aircrew will serve as an additional Lookout if aircraft are used during the activity, when implementing the larger mitigation zone • All divers placing the charges on mines will support the Lookouts while performing their regular duties and will report applicable sightings to their supporting small boat or Range Safety Officer. • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zones: o 500 yards around the detonation site during activities under positive control using 0.1–20 pound net explosive weight o 1,000 yards around the detonation site during activities using time-delay fuses (0.1–20 pound net explosive weight) and during activities under positive control using 21–60 pound net explosive weight charges • Prior to the initial start of the activity (e.g., when maneuvering on station for activities under positive control; 30 minutes for activities using time-delay firing devices): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of detonations or fuse initiation. • During the activity: o Observe in the mitigation zone for marine mammals and sea turtles; if observed, cease detonations or fuse initiation. o To the maximum extent practicable depending on mission requirements, safety, and environmental conditions, boats will position themselves near the mid-point of the mitigation zone radius (but outside of the detonation plume and human safety zone), will position themselves on opposite sides of the detonation location (when two boats are used), and will travel in a circular pattern around the detonation location with one Lookout observing inward toward the detonation site and the other observing outward toward the perimeter of the mitigation zone. o If used, aircraft will travel in a circular pattern around the detonation location to the maximum extent practicable. o The Navy will not set time-delay firing devices (0.1–20 pound net explosive weight) to exceed 10 minutes. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the detonation site; or (3) the

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mitigation zone has been clear from any additional sightings for 10 minutes during activities under positive control with aircraft that have fuel constraints, or 30 minutes during activities under positive control with aircraft that are not typically fuel constrained and during activities using time-delay firing devices. • After completion of an activity (for 30 minutes): o Observe for marine mammals and sea turtles in the vicinity of where detonations occurred; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures. o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

For activities using the 1,000 yard mitigation zone, explosives in bin E7 (e.g., 60 pound net explosive weight charges) have the longest impact ranges. For bin E7, the 1,000 yard mitigation zone extends beyond the average ranges to PTS for all functional hearing groups that could potentially occur in the locations where this activity takes place except low-frequency cetaceans. The mitigation will be more protective during the use of smaller charges with shorter impact ranges, including those using time-delay fuses (e.g., bin E6). For activities using the 500 yard mitigation zone, positive control charges in bin E6 (e.g., 20 pound net explosive weight) have the longest impact ranges. For bin E6, the 500 yard mitigation zone also extends beyond the average ranges to PTS for all functional hearing groups that could potentially occur in the locations where this activity takes place except low-frequency cetaceans. The mitigation will be more protective during the use of smaller positive control charges (e.g., bin E5, bin E4) with shorter impact ranges.

Due to their low vantage point on the water, Lookouts in small boats will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) or the splashes of individual marine mammals than cryptic marine mammal species and sea turtles near the perimeter of the mitigation zone. When rotary-wing aircraft are used, Lookouts positioned in an aircraft will have a better vantage point for observing out to the perimeter of the 1,000 yard or 500 yard mitigation zone. For activities using a time-delay fuse, there is a chance that animals may swim into the mitigation zone after the fuse has been initiated. During activities under positive control, the Navy can cease detonations at any time in response to a sighting of a marine mammal or sea turtle. Observing for indicators of marine mammal and sea turtle presence will help avoid or reduce impacts on these resources within the mitigation zones. The additional mitigation within the Navy Cherry Point Range Complex (Table 30) will help the Navy avoid or reduce impacts on ESA-listed sea turtles during nesting season. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.13 Maritime Security Operations – Anti-Swimmer Grenades

Table 31 describes the proposed procedural mitigation during maritime security operations – anti-swimmer grenades.

Table 31. Procedural mitigation for maritime security operations – anti-swimmer grenades (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Maritime Security Operations – Anti-Swimmer Grenades
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the small boat conducting the activity • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: o 200 yards around the intended detonation location • Prior to the initial start of the activity (e.g., when maneuvering on station): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of detonations. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease detonations. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended detonation location; (3) the mitigation zone has been clear from any additional sightings for 30 minutes.; or (4) the intended detonation location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting. • After completion of the activity (e.g., prior to maneuvering off station): o When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals and sea turtles in the vicinity of where detonations occurred; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures. o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Explosives used during Maritime Security Operations – Anti-Swimmer Grenades exercises are in bin E2 (e.g., 0.5 pound net explosive weight). For bin E2, the mitigation zone extends beyond the average ranges to PTS for all functional hearing groups that could potentially occur in the locations where this activity takes place. The small mitigation zone size will help increase the likelihood that Lookouts will detect marine mammals and sea turtles and observing for indicators of marine mammal and sea turtle presence will help avoid or reduce impacts on these resources within the mitigation zone. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.14 Line Charge Testing

Table 32 describes proposed procedural mitigation for line charge testing. During line charge testing, surface vessels deploy line charges to test the capability to safely clear surf zone areas for sea-based expeditionary forces. Line charges consist of a 350 foot detonation cord with explosives lined from end to end in a series of 5 pound increments.

Table 32. Procedural mitigation for line charge testing (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Line charge testing
Resource Protection Focus • Marine mammals • Sea turtles • Fish (Gulf sturgeon)
Number of Lookouts and Observation Platform • 1 Lookout positioned on a vessel • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: o 900 yards around the intended detonation location • Prior to the initial start of the activity (e.g., when maneuvering on station): o Observe the mitigation zone for floating vegetation; if observed, delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, delay the start of detonations. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease detonations. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended detonation location; or (3) the mitigation zone has been clear from any additional sightings for 30 minutes. • After completion of the activity (e.g., prior to maneuvering off station): o When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe for marine mammals and sea turtles in the vicinity of where detonations occurred; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures. o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred. • Additional requirements: o From March through September (sea turtle nesting season), the Navy will not conduct line charge testing at night. o From October through March (Gulf sturgeon migration season), Navy will not conduct line charge testing except within a designated location on Santa Rosa Island.

The maximum size of explosives used in this activity falls within bin E14 (e.g., 2,500 pound high blast explosive). For bin E14, the mitigation zone extends beyond the average ranges to PTS for all functional hearing groups that could potentially occur in the locations where this activity takes place. Low-frequency cetaceans have average ranges to PTS that are longer than the mitigation zone; however, they are unlikely to occur in the area where this activity takes place. Lookouts will have a better likelihood of detecting sea turtles that are in the near-range or central portion of the mitigation zone because turtles in these areas are closer to the lookout. Observing for indicators of sea turtle presence (e.g., jellyfish, *Sargassum*) will help avoid or reduce impacts on these resources within the mitigation zones.

Naval Surface Warfare Center, Panama City Division Testing Range is currently the Navy's only location capable of supporting line charge testing. Per Table 32, the Navy will also implement a number of seasonal restrictions to minimize the potential for impacts to ESA-listed species in this area. First, not conducting line charge testing at night from March through September (i.e., turtle nesting season in this area) will help avoid or reduce potential impacts on green, Kemp's ridley, loggerhead, and leatherback sea turtles during the time of day when they will be most likely to transit to and from their nesting beaches during nesting season. Additionally, not conducting line charge testing activities from October through March (except within a designated location on Santa Rosa Island, but still within the Panama City Division Testing Range) will help avoid or reduce potential impacts on ESA-listed Gulf sturgeon during their seasonal migration from the Gulf of Mexico winter and feeding grounds to the spring and summer natal (hatching) rivers (the Yellow, Choctawhatchee, and Apalachicola Rivers). The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.15 Ship Shock Trials

Table 33 describes proposed procedural mitigation for ship shock trials.

Table 33. Procedural mitigation for ship shock trials (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Ship shock trials
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • At least 10 Lookouts or trained marine species observers (or a combination thereof) positioned either in an aircraft or on multiple vessels (i.e., a Marine Animal Response Team boat and the test ship) o If aircraft are used, Lookouts or trained marine species observers will be in an aircraft and on multiple vessels o If aircraft are not used, a sufficient number of additional Lookouts or trained marine species observers will be used to provide vessel-based visual observation comparable to that achieved by aerial surveys • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: o 3.5 NM around the ship hull • During event planning: o The Navy will not conduct ship shock trials in the Jacksonville Operating Area during North Atlantic right whale calving season from November 15 through April 15. o The Navy develops detailed ship shock trial monitoring and mitigation plans approximately 1-year prior to an event and will continue to provide these to NMFS for review and approval. o Pre-activity planning will include selection of one primary and two secondary areas where marine mammal populations are expected to be the lowest during the event, with the primary and secondary locations located more than 2 NM from the western boundary of the Gulf Stream for events in the Virginia Capes Range Complex or Jacksonville Range Complex. o If it is determined during pre-activity surveys that the primary area is environmentally unsuitable (e.g., observations of marine mammals or presence of concentrations of floating vegetation), the shock trial could be moved to a secondary site in accordance with the detailed mitigation and monitoring plan provided to NMFS. • Prior to the initial start of the activity at the primary shock trial location (in intervals of 5 hours, 3 hours, 40 minutes, and immediately before the detonation): o Observe the mitigation zone for floating vegetation; if observed, delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, delay triggering the detonation. • During the activity: o Observe the mitigation zone for marine mammals, sea turtles, large schools of fish, jellyfish aggregations, and flocks of seabirds; if observed, cease triggering the detonation. o After completion of each detonation, observe the mitigation zone for marine mammals and sea turtles; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures and halt any remaining detonations until the Navy can consult with NMFS and review or adapt the mitigation, if necessary. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting

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the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the ship hull; or (3) the mitigation zone has been clear from any additional sightings for 30 minutes. • After completion of the activity (during the following 2 days at a minimum, and up to 7 days at a maximum): o Observe for marine mammals and sea turtles in the vicinity of where detonations occurred; if any injured or dead marine mammals or sea turtles are observed, follow established incident reporting procedures. o If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Bin E17 has the longest impact ranges for explosives used during ship shock trials in the action area. For bin E17, the mitigation zone extends beyond the average ranges to PTS for all functional hearing groups with ESA-listed species that could potentially occur in the locations where this activity takes place except low-frequency cetaceans. The mitigation will be more protective for small ship shock trials using explosives in lower bins (e.g., bin E16) with shorter impact ranges.

Lookouts positioned in aircraft will have the best vantage point for observing the large mitigation zone. During small ship shock trials, aerial surveys are not always operationally feasible due to resource limitations; however, if vessels are used as the sole observation platform, the Navy's use of multiple vessels will increase the likelihood that protected species are detected in the mitigation zone.

According to the Navy's BA, the mitigation zone represents the maximum area that will likely be effective at avoiding or reducing impacts on marine mammals and sea turtles during ship shock trials based on the amount of time it takes for vessels and aircraft to patrol the area. The longer a vessel or aircraft spends transiting the survey area, the less focused the survey becomes on observing individuals that may be present close to the detonation. Even with the intensive observation effort that will be used during ship shock trials, there is a chance that animals could enter the mitigation zone at one end while the observation platforms are conducting observations in other locations. Lookouts will have a better likelihood of detecting marine mammals and sea turtles that are in the central portion of the mitigation zone (around the ship hull) and during closer-range observations, but are not likely to detect these resources at the far side of the mitigation zone perimeter because animals will be more difficult to see at far distances. At far distances, Lookouts will have a better likelihood of detecting large visual cues (e.g., whale blows or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles. The Navy will observe for marine mammal and sea turtle indicators during this activity (large schools of fish, jellyfish aggregations, and flocks of seabirds) as an added precaution, which will help avoid or reduce impacts on these resources within the mitigation zone. The post-detonation and post-activity observations for marine mammals and sea turtles will help the Navy determine if any animals were injured during the activity.

3.4.2.1.16 Vessel Movement

Table 34 describes proposed procedural mitigation for vessel movement.

Table 34. Procedural mitigation for vessel movement (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Vessel movement o The mitigation will not be applied if: (1) the vessel's safety is threatened, (2) the vessel is restricted in its ability to maneuver (e.g., during launching and recovery of aircraft or landing craft, during towing activities, when mooring, etc.), or (3) the vessel is operated autonomously.
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout on the vessel that is underway
Mitigation Requirements • Mitigation zones: o 500 yards around whales o 200 yards around other marine mammals (except bow-riding dolphins and pinnipeds hauled out on man-made navigational structures, port structures, and vessels) o Within the vicinity of sea turtles • During the activity: o When underway, observe the mitigation zone for marine mammals and sea turtles; if observed, maneuver to maintain distance. • Additional requirements: o The Navy will broadcast awareness notification messages with North Atlantic right whale Dynamic Management Area information (e.g., location and dates) to applicable Navy assets operating in the vicinity of the Dynamic Management Area. The information will alert assets to the possible presence of a North Atlantic right whale to maintain safety of navigation and further reduce the potential for a vessel strike. Platforms will use the information to assist their visual observation of applicable mitigation zones during training and testing activities and to aid in the implementation of procedural mitigation, including but not limited to mitigation for vessel movement. o If a marine mammal vessel strike occurs, the Navy will follow the established incident reporting procedures.

3.4.2.1.17 Towed In-Water Devices

Table 35 describes proposed procedural mitigation for towed in-water devices. Vessels involved in towing in-water devices will implement the mitigation described for vessel movement in Table 35, in addition to the mitigation outlined for towed in-water devices in Table 34.

Table 35. Procedural mitigation for towed in-water devices (Navy 2018a).

Procedural Mitigation Description

Stressor or Activity
• Towed in-water devices
  o Mitigation applies to devices that are towed from a manned surface platform or manned aircraft
  o The mitigation will not be applied if the safety of the towing platform or in-water device is threatened

Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the manned towing platform

Mitigation Requirements
• Mitigation zones:
  o 250 yards around marine mammals
  o Within the vicinity of sea turtles
• During the activity (i.e., when towing an in-water device)
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, maneuver to maintain distance.

3.4.2.1.18 Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions

Table 36 describes proposed procedural mitigation for the use of small-, medium-, and large-caliber non-explosive practice munitions.

Table 36. Procedural mitigation for small-, medium-, and large-caliber non-explosive practice munitions (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using small-, medium-, and large-caliber non-explosive practice munitions   o Mitigation applies to activities using a surface target
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the platform conducting the activity   o Depending on the activity, the Lookout could be the same as the one described for Weapons Firing Noise.

Mitigation Requirements
• Mitigation zone:
  o 200 yards around the intended impact location
• Prior to the initial start of the activity (e.g., when maneuvering on station):
  o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear.
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of firing.
• During the activity:
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease firing.
• Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity:
  o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; (3) the mitigation zone has been clear from any additional sightings for 10 minutes for aircraft-based firing or 30 minutes for vessel-based firing; or (4) for activities using a mobile target, the intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

The mitigation zone for this activity is several times larger than the impact footprint for all projectiles used for these activities (See Appendix F, Military Expended Material and Direct Strike Impact Analysis, of the AFTT DEIS/OEIS for additional detail).

Large-caliber gunnery activities involve the firing of projectiles at a target located up to 6 NM down range from the firing ship. Small- and medium-caliber gunnery activities involve vessels or aircraft firing projectiles at targets that may be located up to 4,000 yards from the firing platform, although typically the targets for these activities are much closer. Lookouts will have a better likelihood of detecting marine mammals and sea turtles when observing mitigation zones around targets that are located close to the firing platform. When observing activities that use a target located far from the firing platform, Lookouts will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles.

3.4.2.1.19 Non-Explosive Missiles and Rockets

Table 37 describes the proposed procedural mitigation for the use of non-explosive missiles and rockets.

Table 37. Procedural mitigation for non-explosive missiles and rockets (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Aircraft-deployed non-explosive missiles and rockets   o Mitigation applies to activities using a surface target
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft

Mitigation Requirements
• Mitigation zone:
  o 900 yards around the intended impact location
• Prior to the initial start of the activity (e.g., during a fly-over of the mitigation zone):
  o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear.
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of firing.
• During the activity:
  o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease firing.
• Commencement/recommencement conditions after a marine mammal or sea turtle sighting prior to or during the activity:
  o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; or (3) the mitigation zone has been clear from any additional sightings for 10 minutes when the activity involves aircraft that have fuel constraints, or 30 minutes when the activity involves aircraft that are not typically fuel constrained.

The mitigation zone for this activity is several times larger than the impact footprint for all non-explosive missiles and rockets proposed for use (See Appendix F, Military Expended Material and Direct Strike Impact Analysis, of the AFTT DEIS/OEIS for further detail).

Missile and rocket exercises involve a participating ship or aircraft firing munitions at a target that is typically located up to 15 NM away, and infrequently up to 75 NM away. The mitigation only applies to aircraft-deployed missiles and rockets because aircraft can travel close to the intended impact area prior to commencing firing. Observation of the mitigation zone is not possible when missiles and rockets are fired from a ship due to the distance between the firing ship and the intended impact location. Even when aircraft are firing, there is a chance that animals could enter the mitigation zone after the aircraft conducts its close-range mitigation zone observations and before firing begins (once the aircraft has transited to its distant firing position). Due to the distance between the mitigation zone and the observation platform, Lookouts will have a better likelihood of detecting marine mammals and sea turtles during the close-range observations.

3.4.2.1.20 Non-Explosive Bombs and Mine Shapes

Table 38 describes the proposed procedural mitigation for the use of non-explosive bombs and mine shapes.

Table 38. Procedural mitigation for non-explosive bombs and mine shapes (Navy 2018a).

Procedural Mitigation Description
Stressor or Activity • Non-explosive bombs • Non-explosive mine shapes during mine laying activities
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft
Mitigation Requirements • Mitigation zone: o 1,000 yards around the intended target • Prior to the start of the activity (e.g., when arriving on station): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of bomb deployment or mine laying. • During the activity (e.g., during approach of the target or intended minefield location): o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease bomb deployment or mine laying. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting prior to or during the activity: o The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing bomb deployment or mine laying) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target or minefield location; (3) the mitigation zone has been clear from any additional sightings for 10 minutes; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

The mitigation zone for this activity is several times larger than the impact footprint for non-explosive bombs and mine shapes (See Appendix F, Military Expended Material and Direct Strike Impact Analysis, of the AFTT DEIS/OEIS for further detail).

Bombing exercises and activities involving mine laying involve a participating aircraft deploying munitions or mine shapes at a surface target or in an intended minefield location beneath the platform. During approach of the target or intended minefield location, aircraft maintain a relatively steady altitude of approximately 1,500 ft, and Lookouts will, by necessity for safety and mission success, primarily focus their attention on the water surface below and surrounding the location of bomb or mine shape deployment. Due to the mitigation zone size and vantage point from an aircraft, Lookouts should be able to observe the entire mitigation zone while still maintaining situational awareness (Navy 2017a). Observing for indicators of marine mammal and sea turtle presence will help avoid or reduce impacts on these resources within the mitigation zone.

3.4.2.2 Mitigation Areas

In addition to procedural mitigation, the Navy will implement mitigation measures within specified areas to avoid potential impacts on marine mammals (including ESA-listed species) and seafloor resources (which serve valuable ecosystem functions and provide habitat for ESA-listed species and their prey). Mitigation areas are geographic locations in the action area where the Navy will implement additional avoidance and minimization measures during all or a part of the year.

The Navy considered several factors when determining the location of proposed geographic mitigation areas. First, they evaluated whether the mitigation area will be effective in reducing impacts to resources of biological or ecological importance. Next, the Navy operational community assessed how and to what degree implementation of mitigation measures will be compatible with planning, scheduling, and conducting proposed training and testing activities. A more thorough discussion on the factors used by the Navy to determine which areas to propose for geographic mitigation is provided in Section 5.4 (Mitigation Areas to be Implemented) of the AFTT DEIS/OEIS (Navy 2017c).

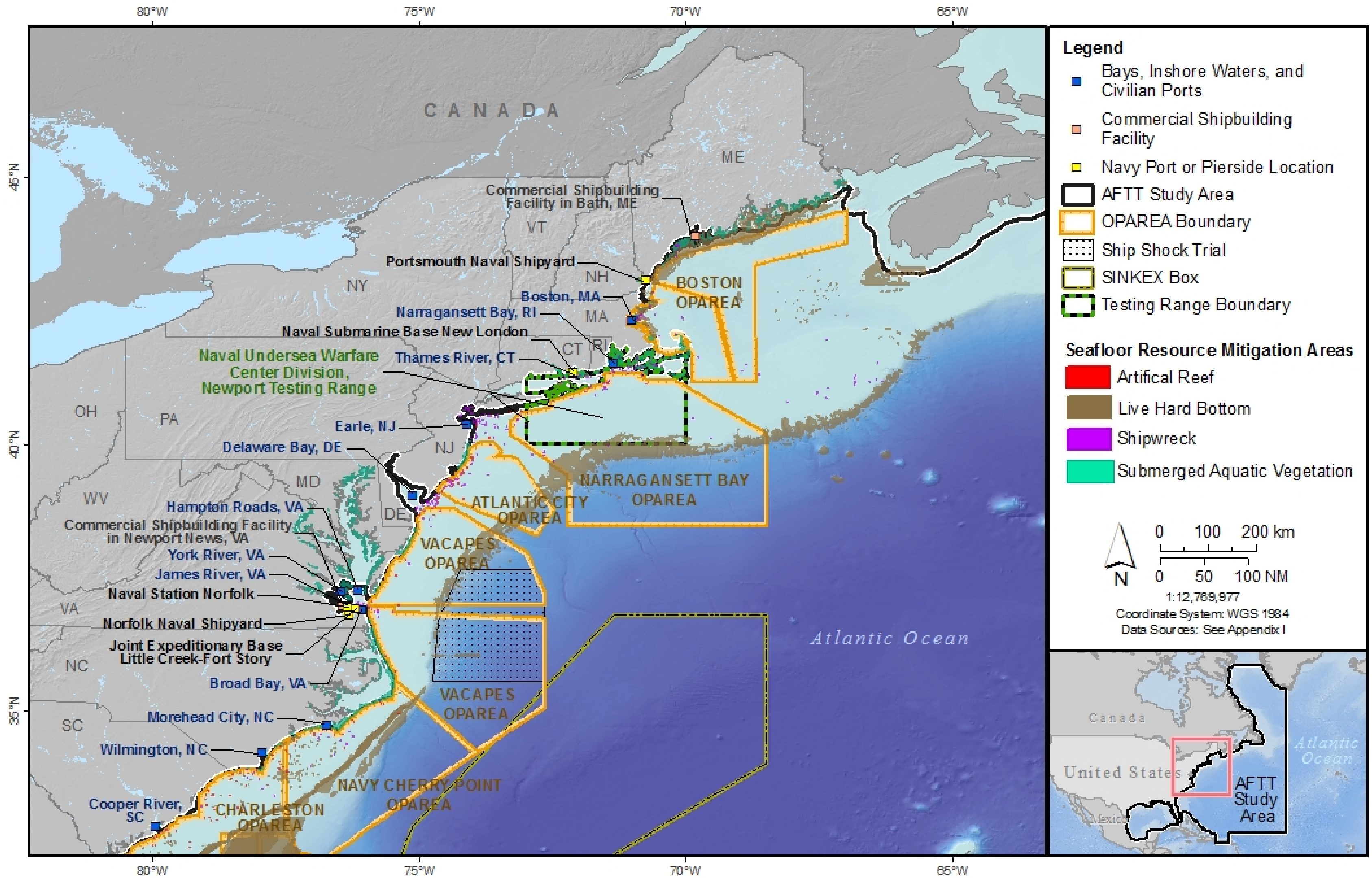
Information on mitigation the Navy proposes to implement within specific geographic areas is provided in the following sections. The mitigation applies year-round unless specified otherwise.

3.4.2.2.1 Mitigation Areas for Seafloor Resources

As described in Table 39 and shown in Figure 11, Figure 12, and Figure 13, the Navy proposes to implement mitigation to avoid and minimize impacts to seafloor resources from explosives, physical disturbance, and strike stressors in mitigation areas throughout the action area. Mitigation will help the Navy avoid or reduce impacts from explosives, physical disturbance, and strike stressors on seafloor resources, and consequently to any ESA-listed resources that inhabit, shelter, rest, feed, or occur in the mitigation areas.

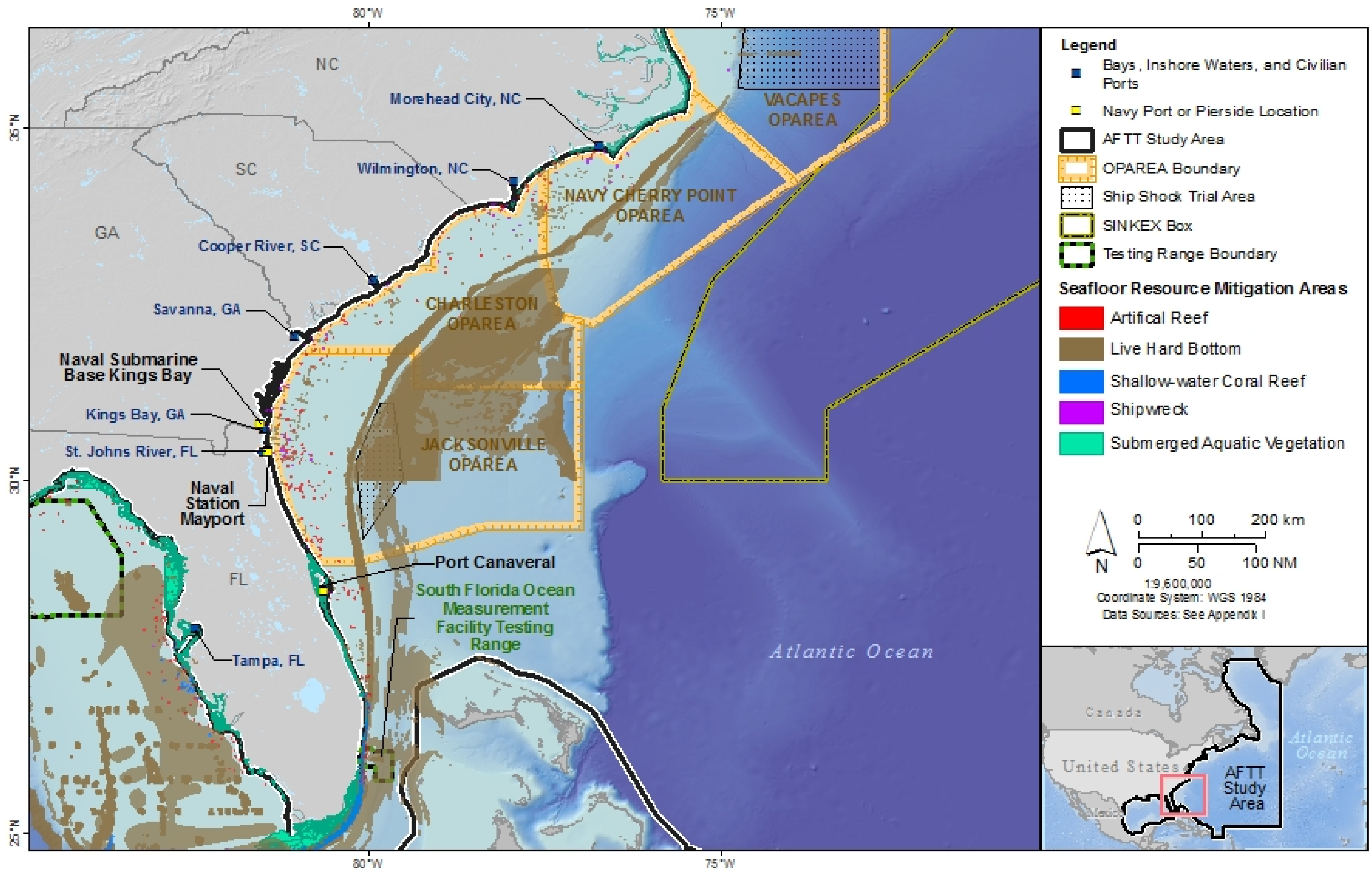
Table 39. Mitigation areas for seafloor resources (Navy 2018a).

Mitigation Area Description
Stressor or Activity • Explosives • Physical disturbance and strikes
Resource Protection Focus • Shallow-water coral reefs • Live hard bottom • Artificial reefs • Submerged aquatic vegetation • Shipwrecks
Mitigation Area Requirements (year-round) • **Within the anchor swing circle of shallow-water coral reefs, live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks:** o The Navy will not conduct precision anchoring (except in designated anchorages). • **Within a 350 yard radius of live hard bottom, artificial reefs, submerged aquatic vegetation, and shipwrecks:** o The Navy will not conduct explosive mine countermeasure and neutralization activities or explosive mine neutralization activities involving Navy divers (except in designated locations, such as Truman Harbor and Demolition Key, where these resources will be avoided to the maximum extent practicable). o The Navy will not place mine shapes, anchors, or mooring devices on the seafloor. • **Within a 350 yard radius of shallow-water coral reefs:** o The Navy will not conduct explosive or non-explosive small-, medium-, and large-caliber gunnery activities using a surface target; explosive or non-explosive missile and rocket activities using a surface target; explosive or non-explosive bombing and mine laying activities; explosive or non-explosive mine countermeasure and neutralization activities; and explosive or non-explosive mine neutralization activities involving Navy divers. o The Navy will not place mine shapes, anchors, or mooring devices on the seafloor. • **Within the Key West Range Complex:** o Vessels will operate within waters deep enough to avoid bottom scouring or prop dredging, with at least a one foot clearance between the deepest draft of the vessel (with the motor down) and the seafloor at mean low water. • **Within the South Florida Ocean Measurement Facility Testing Range:** o 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 and during deployment of bottom-crawling unmanned underwater vehicles in waters deeper than 10 feet to avoid shallow-water coral reefs and live hard bottom. o Vessels deploying anchors, mine-like objects, and bottom-crawling unmanned underwater vehicles will aim to hold a relatively fixed position over the intended mooring or deployment location using a dynamic positioning navigation system with global positioning system. o The Navy will minimize vessel movement and drift in accordance with mooring installation and deployment plans and will conduct activities during sea and wind conditions that allow vessels to maintain position and speed control during deployment, installation, and recovery of anchors, mine-like objects, and bottom-crawling unmanned underwater vehicles. o Vessels will operate within waters deep enough to avoid bottom scouring or prop dredging, with at least a 1-ft. clearance between the deepest draft of the vessel (with the motor down) and the seafloor at mean low water. o The Navy will not anchor vessels or spud over shallow-water coral reefs and live hard bottom. o The Navy will use semi-permanent anchoring systems that are assisted with riser buoys over soft bottom habitats to avoid contact of mooring cables with shallow-water coral reefs and live hard bottom.



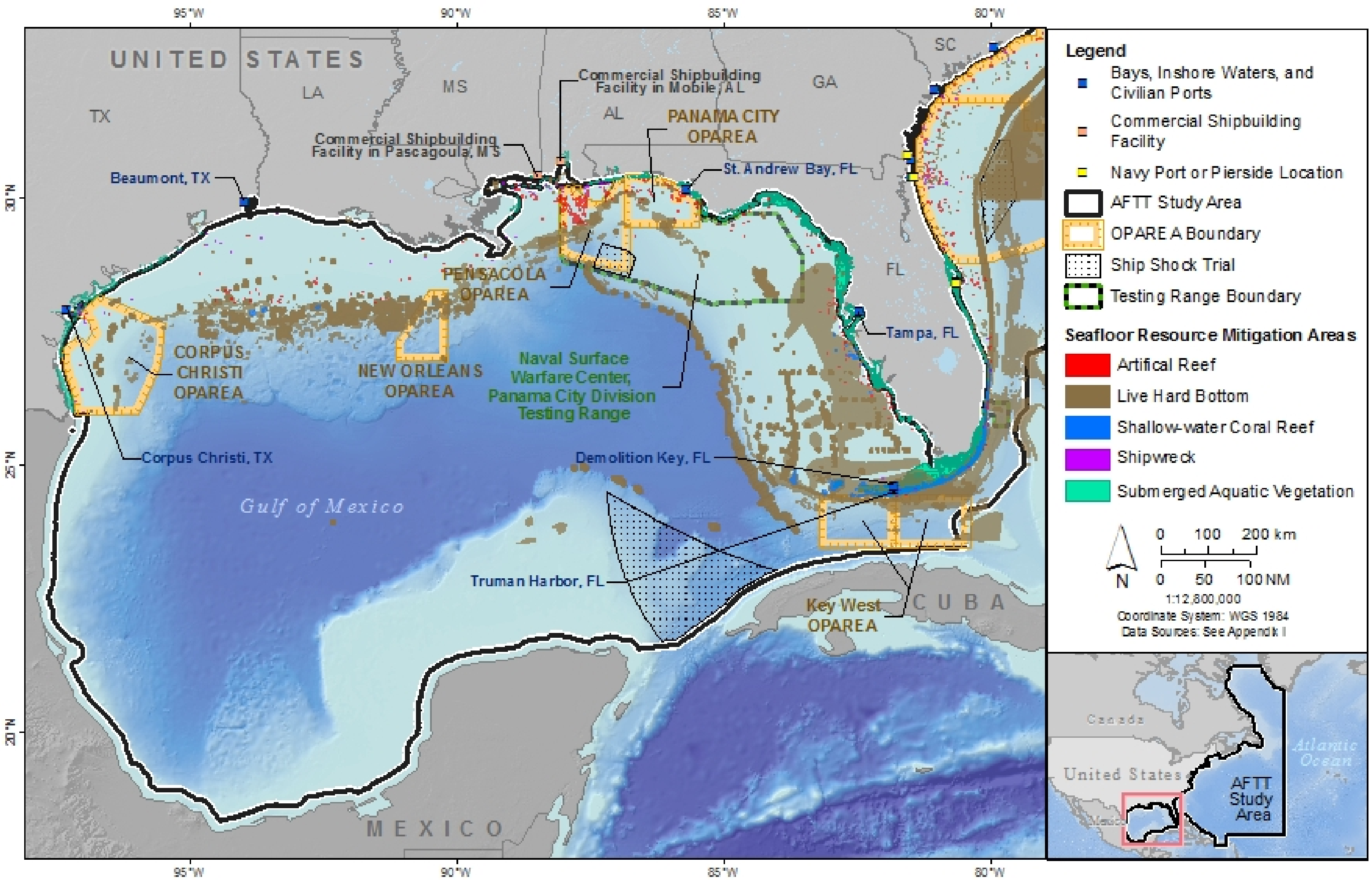
Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: sinking exercise; VACAPES: Virginia Capes

Figure 11. Seafloor resource mitigation areas off the Northeastern United States (Navy 2018a).



Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: sinking exercise; VACAPES: Virginia Capes

Figure 12. Seafloor resource mitigation areas off the Mid-Atlantic and Southeastern United States (Navy 2018a).



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

Figure 13. Seafloor resource mitigation areas in the Gulf of Mexico (Navy 2018a).

The Navy developed proposed mitigation areas as either the anchor swing circle diameter or a 350 yard radius around a mapped seafloor resource, as indicated by the best available georeferenced data. Mitigating within the anchor swing circle will allow protection of seafloor resources during precision anchoring activities when factoring in environmental conditions that could affect anchoring position and swing circle size (such as winds, currents, and water depth). For other activities applicable to the mitigation, a 350 yard radius around a seafloor resource is a conservatively sized mitigation area that will provide protection well beyond the maximum expected impact footprint (e.g., crater and expelled material radius) of the explosives and non-explosive practice munitions used in the action area. As described further in Appendix F (Military Expended Material and Direct Strike Impact Analysis) of the AFTT DEIS/OEIS (Navy 2017c), the military expended material with the largest footprint that applies to the mitigation is an explosive mine with a 650-pound net explosive weight, which has an estimated impact footprint of approximately 14,800 ft^2 and an associated radius of 22.7 yards.

To aid in the implementation of seafloor resource mitigation, the Navy will include maps of the best available georeferenced data (i.e., where the available data accurately indicate the natural boundary of a seafloor resource and are not generalized within large geometric areas, such as large grid cells) in the Protective Measures Assessment Protocol (See Section 3.4.2) for shallow-water coral reefs, artificial reefs, live hard bottom, and shipwrecks.

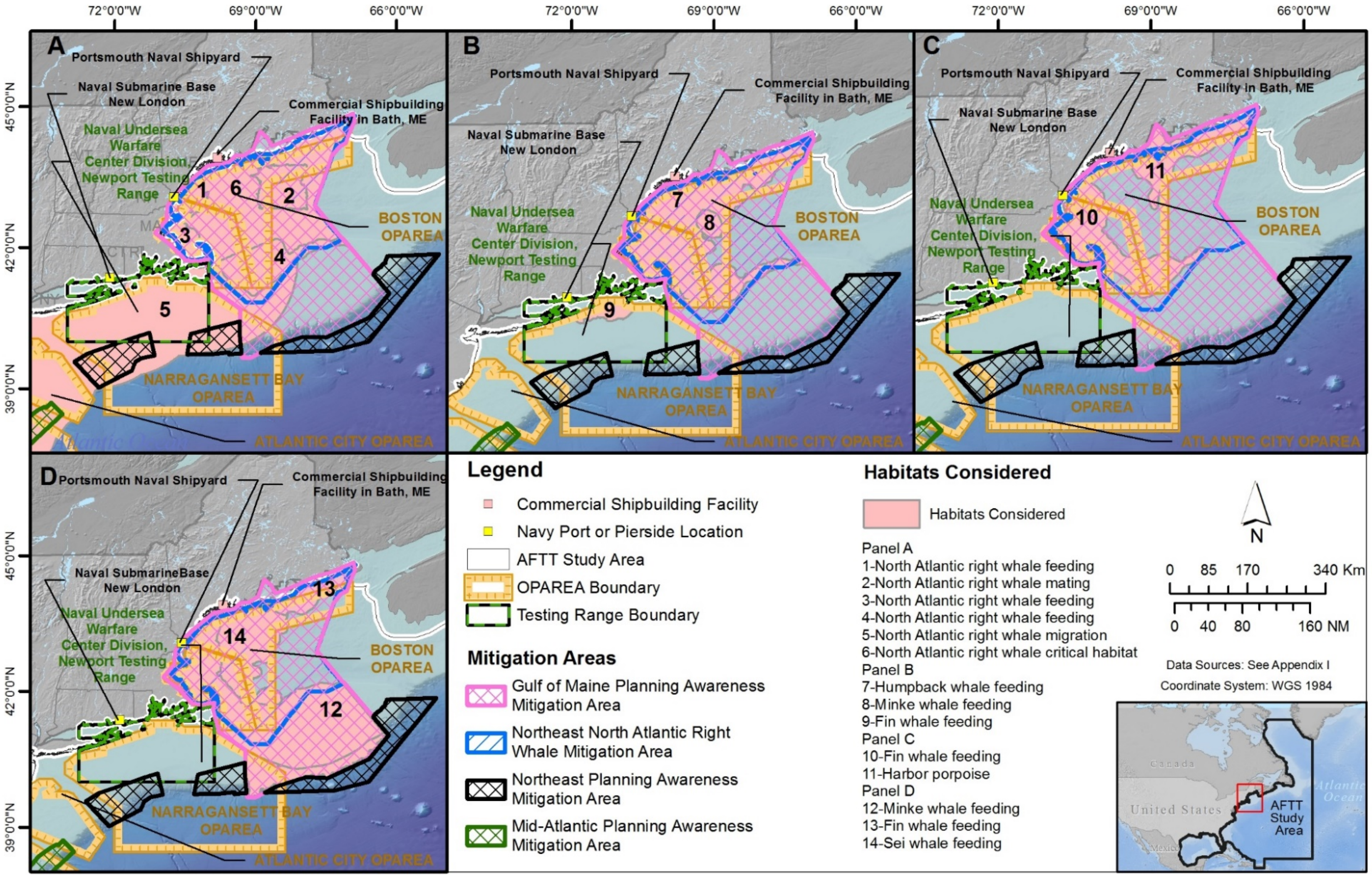
3.4.2.2.2 Mitigation Areas Off the Northeastern United States

The Navy proposes to implement the mitigation described in Table 40 within the action area shown in Figure 14 to avoid or reduce impacts to marine mammals from acoustic, explosive, and physical disturbance and strike stressors from training and testing activities in waters off the northeastern United States.

Table 40. Mitigation areas off the Northeastern United States (Navy 2018a).

Mitigation Area Description
Stressor or Activity • Sonar • Explosives • Physical disturbance and strikes
Resource Protection Focus • Marine mammals
Mitigation Area Requirements (year-round) • **Northeast North Atlantic Right Whale Mitigation Area:** o The Navy will report the total hours and counts of active sonar and in-water explosives used in the mitigation area in its annual training and testing activity reports submitted to NMFS. o The Navy will minimize the use of low-frequency active sonar, mid-frequency active sonar, and high-frequency active sonar to the maximum extent practicable within the mitigation area. o The Navy will not use Improved Extended Echo Ranging sonobuoys (within 3 NM of the mitigation area), explosive and non-explosive bombs, in-water detonations, and explosive torpedoes within the mitigation area. o For activities using non-explosive torpedoes within the mitigation area, the Navy will conduct activities during daylight hours in Beaufort sea state 3 or less. The Navy will use three Lookouts (one positioned on a vessel and two in an aircraft during dedicated aerial surveys) to observe the vicinity of the activity. An additional Lookout will be positioned on the submarine, when surfaced. Immediately prior to the start of the activity, Lookouts will observe for floating vegetation and marine mammals; if observed, the activity will not commence until the vicinity is clear or the activity is relocated to an area where the vicinity is clear. During the activity, Lookouts will observe for marine mammals; if observed, the activity will cease. To allow a sighted marine mammal to leave the area, the Navy will not recommence the activity until one of the following conditions has been met: (1) the animal is observed exiting the vicinity of the activity; (2) the animal is thought to have exited the vicinity of the activity based on a determination of its course, speed, and movement relative to the activity location; or (3) the area has been clear from any additional sightings for 30 minutes. During transits and normal firing, ships will maintain a speed of no more than 10 knots. During submarine target firing, ships will maintain speeds of no more than 18 knots. During vessel target firing, vessel speeds may exceed 18 knots for brief periods of time (e.g., 10–15 minutes). o Before vessel transits within the mitigation area, the Navy will conduct a web query or email inquiry to the National Oceanographic and Atmospheric Administration Northeast Fisheries Science Center's North Atlantic Right Whale Sighting Advisory System to obtain the latest North Atlantic right whale sightings information. Vessels will use the sightings information to reduce potential interactions with North Atlantic right whales during transits. Vessels will implement speed reductions within the mitigation area after observing a North Atlantic right whale, if transiting within 5 NM of a sighting reported to the North Atlantic Right Whale Sighting Advisory System within the past week, and if transiting at night or during periods of reduced visibility. • **Gulf of Maine Planning Awareness Mitigation Area:** o The Navy will report the total hours and counts of active sonar and in-water explosives used in the mitigation area in its annual training and testing activity reports submitted to NMFS. o The Navy will not conduct >200 hours of hull-mounted mid-frequency active sonar per year within the mitigation area. o The Navy will not conduct major training exercises (Composite Training Unit Exercises or Fleet Exercises/Sustainment Exercises) within the mitigation area. If the Navy needs to conduct a major training exercise within the mitigation area in support of training requirements driven by national security concerns, it will confer with NMFS to verify that potential impacts are adequately addressed in the Navy's Final EIS/OEIS and associated consultation documents. • **Northeast Planning Awareness Mitigation Areas:**

Mitigation Area Description
o The Navy will avoid conducting major training exercises (Composite Training Unit Exercises or Fleet Exercises/Sustainment Exercises) within the mitigation area to the maximum extent practicable. o The Navy will not conduct more than four major training exercises per year within the mitigation area (all or a portion of the exercise). If the Navy needs to conduct additional major training exercises in the mitigation area in support of training requirements driven by national security concerns, it will provide NMFS with advance notification and include the information in its annual training and testing activity reports submitted to NMFS.



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

Figure 14. Mitigation areas and habitats considered off the northeastern United States (Navy 2018a).

The Navy uses the Northeast Range Complexes and adjacent waters to support major training exercises, torpedo exercises, tracking exercises, Civilian Port Defense – Homeland Security Anti-Terrorism/Force Protection exercises, missile and rocket exercises, Maritime Security Operations – Anti-Swimmer Grenades activities, gunnery exercises, submarine sonar maintenance and system checks, kilo dip tests, at-sea sonar testing, acoustic and oceanographic research, and other training and testing activities. Implementing the mitigation within mitigation areas off the northeastern United States is expected to result in an avoidance or substantial reduction of impacts on marine mammal species (including ESA-listed fin, sei and North Atlantic right whales) in these areas.

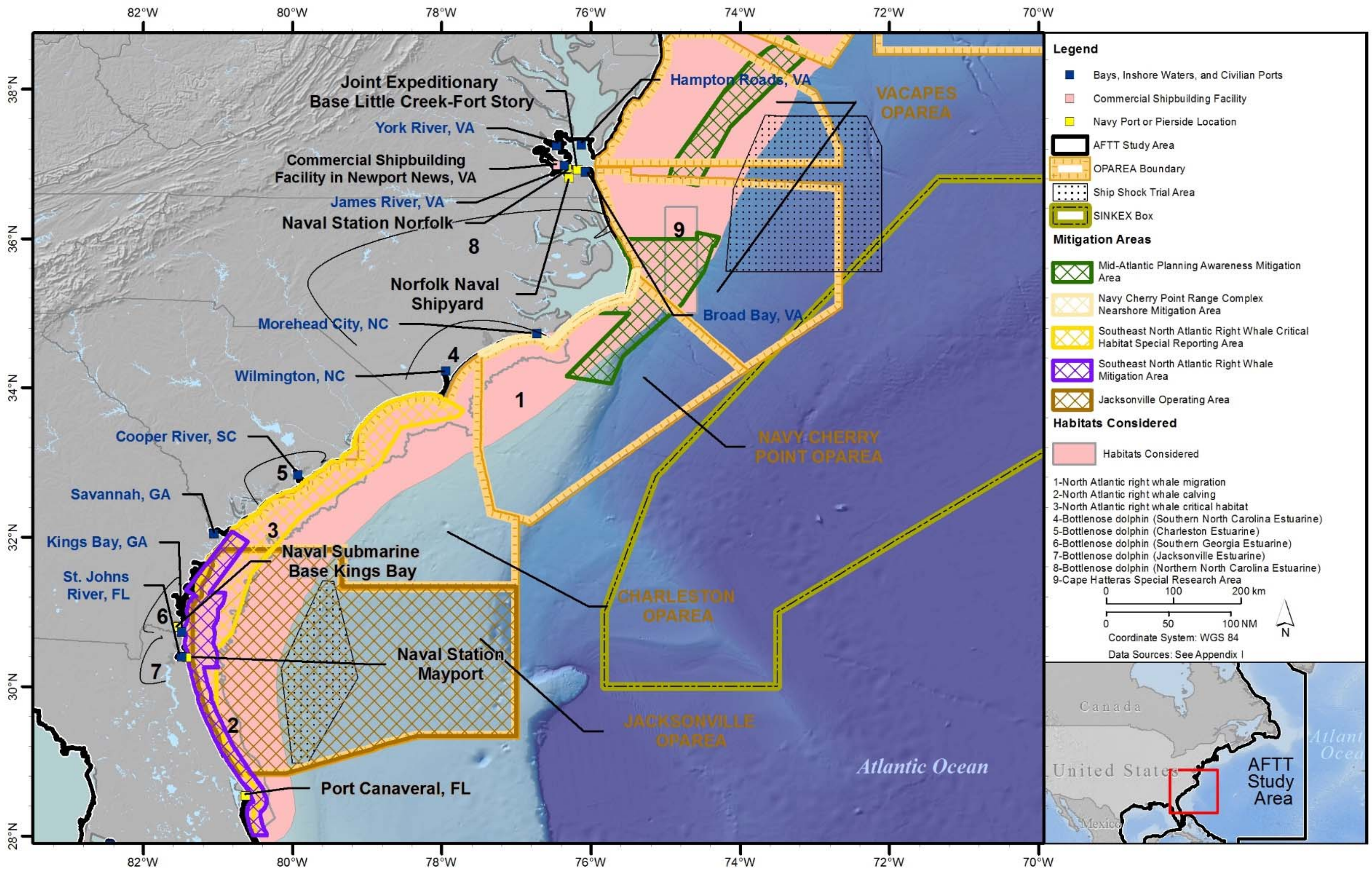
3.4.2.2.3 Mitigation Areas Off the Mid-Atlantic and Southeastern United States

The Navy proposes to implement the mitigation described in Table 41 and shown in Figure 15 to avoid or reduce impacts to marine mammals from acoustic, explosive, and physical disturbance and strike stressors from training and testing activities in waters off the Mid-Atlantic and Southeastern United States.

Table 41. Mitigation areas off the Mid-Atlantic and Southeastern United States (Navy 2018a).

Mitigation Area Description
Stressor or Activity • Sonar • Explosives • Physical disturbance and strikes
Resource Protection Focus • Marine mammals
Mitigation Area Requirements • **Southeast North Atlantic Right Whale Mitigation Area (November 15 through April 15):** o The Navy will report the total hours and counts of active sonar and in-water explosives used in the mitigation area in its annual training and testing activity reports submitted to NMFS. o The Navy will not conduct: (1) low-frequency active sonar (except as noted below), (2) mid-frequency active sonar (except as noted below), (3) high-frequency active sonar, (4) missile and rocket activities (explosive and non-explosive), (5) small-, medium-, and large-caliber gunnery activities, (6) Improved Extended Echo Ranging sonobuoy activities, (7) explosive and non-explosive bombing activities, (8) in-water detonations, and (9) explosive torpedo activities within the mitigation area. o To the maximum extent practicable, the Navy will minimize the use of: (1) helicopter dipping sonar, (2) low-frequency active sonar and hull-mounted mid-frequency active sonar used for navigation training, and (3) low-frequency active sonar and hull-mounted mid-frequency active sonar used for object detection exercises within the mitigation area. o Before transiting or conducting training or testing activities within the mitigation area, the Navy will initiate communication with the Fleet Area Control and Surveillance Facility, Jacksonville to obtain Early Warning System North Atlantic right whale sightings data. The Fleet Area Control and Surveillance Facility, Jacksonville will advise vessels of all reported whale sightings in the vicinity to help vessels and aircraft reduce potential interactions with North Atlantic right whales. Commander Submarine Force U.S. Atlantic Fleet will coordinate any submarine activities that may require approval from the Fleet Area Control and Surveillance Facility, Jacksonville. Vessels will use the sightings information to reduce potential interactions with North Atlantic right whales during transits. o Vessels will implement speed reductions after they observe a North Atlantic right whale, if they are within 5 NM of a sighting reported within the past 12 hours, or when operating in the mitigation area at night or during periods of poor visibility. o To the maximum extent practicable, vessels will minimize north-south transits in the mitigation area. • **Jacksonville Operating Area (November 15 through April 15):** o Navy units conducting training or testing activities in the Jacksonville Operating Area will initiate communication with the Fleet Area Control and Surveillance Facility, Jacksonville to obtain Early Warning System North Atlantic right whale sightings data. The Fleet Area Control and Surveillance Facility, Jacksonville will advise vessels of all reported whale sightings in the vicinity to help vessels and aircraft reduce potential interactions with North Atlantic right whales. Commander Submarine Force U.S. Atlantic Fleet will coordinate any submarine activities that may require approval from the Fleet Area Control and Surveillance Facility, Jacksonville. The Navy will use the reported sightings information as it plans specific details of events (e.g., timing, location, duration) to minimize potential interactions with North Atlantic right whales to the maximum extent practicable. The Navy will use the reported sightings information to assist visual observations of applicable mitigation zones and to aid in the implementation of procedural mitigation. • **Southeast North Atlantic Right Whale Critical Habitat Special Reporting Area (November 15 through April 15):**

Mitigation Area Description
o The Navy will report the total hours and counts of active sonar and in-water explosives used in the Special Reporting Area (i.e., the southeast North Atlantic right whale critical habitat) in its annual training and testing activity reports submitted to NMFS. • **Mid-Atlantic Planning Awareness Mitigation Areas (year-round):** o The Navy will avoid conducting major training exercises within the mitigation area (Composite Training Unit Exercises or Fleet Exercises/Sustainment Exercises) to the maximum extent practicable. o The Navy will not conduct more than four major training exercises per year (all or a portion of the exercise) within the mitigation area. If the Navy needs to conduct additional major training exercises in the mitigation area in support of training requirements driven by national security concerns, it will provide NMFS with advance notification and include the information in its annual training and testing activity reports submitted to NMFS. • **Navy Cherry Point Range Complex Nearshore Mitigation Area (March through September):** o The Navy will not conduct explosive mine neutralization activities involving Navy divers in the mitigation area. o To the maximum extent practicable, the Navy will not use explosive sonobuoys, explosive torpedoes, explosive medium-caliber and large-caliber projectiles, explosive missiles and rockets, explosive bombs, explosive mines during mine countermeasure and neutralization activities, and anti-swimmer grenades in the mitigation area.



Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: sinking exercise; VACAPES: Virginia Capes

Figure 15. Mitigation areas and habitats considered off the Mid-Atlantic and Southeastern United States (Navy 2018a).

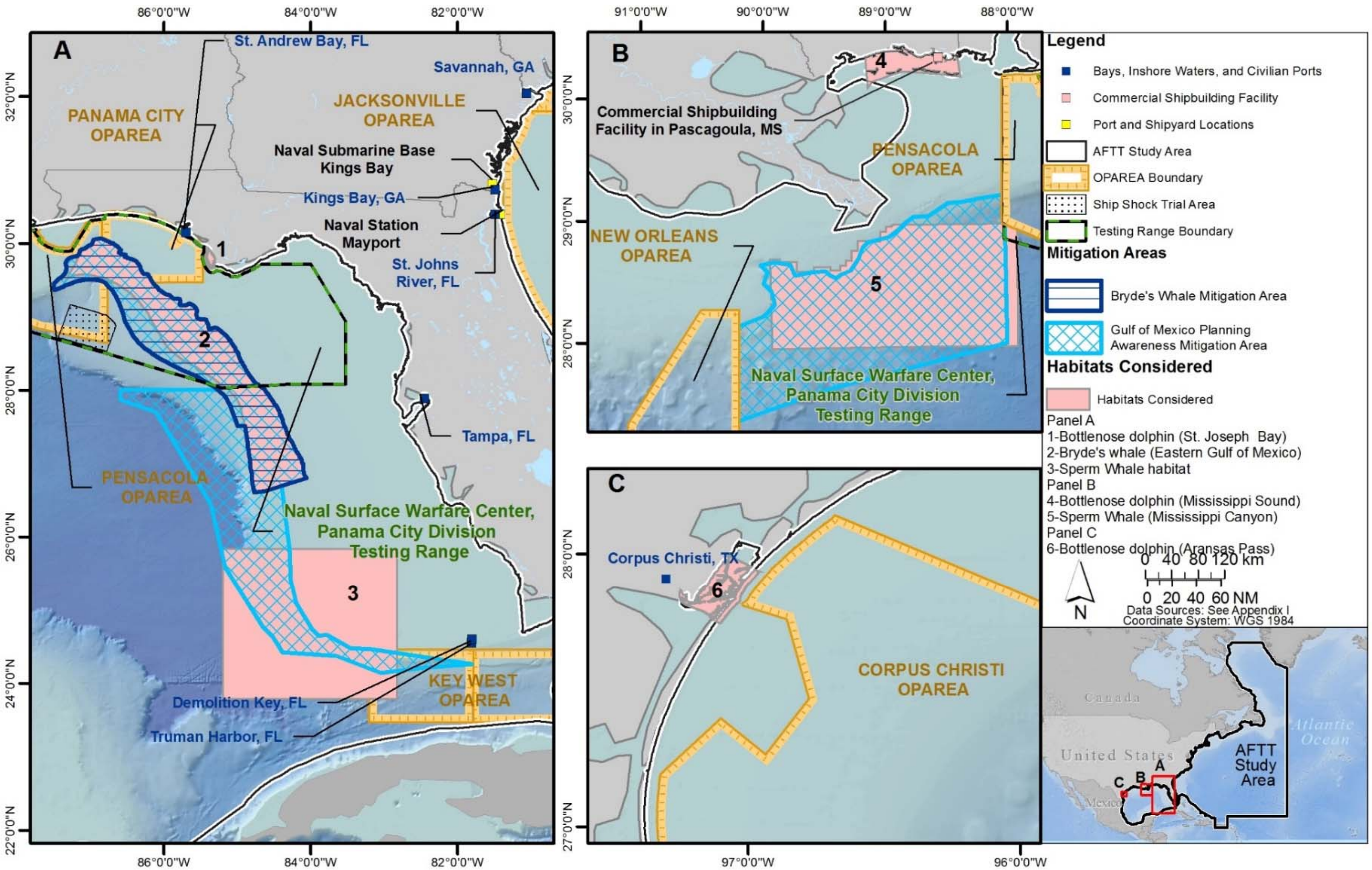
The waters off the mid-Atlantic and southeastern United States encompass part of the primary water space in the action area where unit-level training, integrated training, and deployment certification exercises occur. The Navy also uses waters off the mid-Atlantic and southeastern United States for testing components of air warfare, mine warfare, surface warfare, anti-submarine warfare, electronic warfare, vessels and vessel signatures, unmanned systems; and other testing, such as chemical and biological simulant testing. Within nearshore areas, the Navy conducts pierside sonar testing at Kings Bay, Georgia; Norfolk, Virginia; and Port Canaveral, Florida. Implementing the mitigation within mitigation areas off the mid-Atlantic and southeastern United States will result in an avoidance or reduction of impacts on marine mammal species (including ESA-listed North Atlantic right whales) in these areas.

3.4.2.2.4 Mitigation Areas in the Gulf of Mexico

The Navy proposes to implement the mitigation described in Table 42 and shown in Figure 16 to avoid or reduce impacts to marine mammals from acoustic, explosive, and physical disturbance and strike stressors from training and testing activities in water of the Gulf of Mexico.

Table 42. Mitigation areas in the Gulf of Mexico (Navy 2018a).

Mitigation Area Description
Stressor or Activity • Sonar • Explosives
Resource Protection Focus • Marine mammals
Mitigation Area Requirements (year-round) • **Bryde's Whale Mitigation Area:** o The Navy will report the total hours and counts of active sonar and in-water explosives used in the mitigation area in its annual training and testing activity reports submitted to NMFS. o The Navy will not conduct >200 hours of hull-mounted mid-frequency active sonar per year within the mitigation area. o The Navy will not use explosives (except during mine warfare activities) within the mitigation area. • **Gulf of Mexico Planning Awareness Mitigation Areas:** o The Navy will not conduct any major training exercises within the mitigation areas (all or a portion of the exercise) under the Proposed Action. o If the Navy needs to conduct a major training exercise within the mitigation areas in support of training requirements driven by national security concerns, it will confer with NMFS to verify that potential impacts are adequately addressed in the Navy's Final EIS/OEIS and associated consultation documents.



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

Figure 16. Mitigation areas in the Gulf of Mexico (Navy 2018a).

The Gulf of Mexico encompasses part of the primary water space in the action area where unit-level training, integrated training, and deployment certification exercises occur. The Navy also uses the Gulf of Mexico for testing components of air warfare, mine warfare, surface warfare, anti-submarine warfare, electronic warfare, vessels and vessel signatures, unmanned systems; and other testing including submersibles, line charges, and semi-stationary equipment testing. The Navy developed the mitigation areas identified in Table 42 to minimize the potential for impacts to marine mammals during training and testing activities in areas that are important to small and resident populations of Bryde's whales and sperm whales. Implementing the mitigation within the Gulf of Mexico Planning Awareness Mitigation Areas is expected to result in an avoidance or reduction of impacts from active sonar on these species (included ESA-listed sperm whales) in these areas.

4 Action Area

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 C.F.R. §402.02). The action area for this consultation is the AFTT Study Area (Figure 8), described in further detail in Section 3.1 of this opinion.

5 Interrelated and Interdependent Actions

Interrelated actions are those that are part of a larger action and depend on that action for their justification. *Interdependent* actions are those that do not have independent utility apart from the action under consideration. We determined that there are no interrelated or interdependent actions to the actions proposed by the Navy and NMFS Permits Division, as described in Section 2.3 of this opinion.

6 Potential Stressors

The potential stressors we expect to result from the proposed action are acoustic stressors, explosive stressors, energy stressors, physical disturbance and strike, entanglement, and ingestion. Further discussion of each of these stressors is below.

6.1 Acoustic Stressors

Acoustic stressors include acoustic signals emitted into the water for a specific purpose (e.g., by active sonars and air guns), as well as incidental sources of broadband sound produced as a byproduct of vessel movement; aircraft transits; pile driving and removal; and use of weapons or other deployed objects. Explosives also produce broadband sound but are characterized separately from other acoustic sources due to their unique energetic characteristics.

6.1.1 Vessel Noise

Naval vessels (including ships and small craft) produce low-frequency, broadband underwater sound, though the exact level of noise produced varies by vessel type. Navy vessels represent a small amount of overall vessel traffic and an even smaller amount of overall vessel traffic noise in the action area because many Navy ships incorporate quieting technology that other vessels (e.g., commercial ships) do not (Mintz and Filadelfo 2011a; Mintz 2012b). As shown in Table 43, Navy ships make up roughly one percent (i.e., 0.7 percent) of the vessel presence in the action area. Navy ship traffic is more concentrated around the homeports of Norfolk, Virginia and Jacksonville, Florida. The Navy contributes one percent of radiated broadband noise in the Virginia Capes and Jacksonville Range Complexes (Mintz and Filadelfo 2011a).

Table 43. The Navy's estimate of vessel presence in the action area (Navy 2017a).

Ship Category	AFTT
Non-military	9,970,244
Military	72,094

Notes: Ship-hours were calculated from representative data to assess the relative contribution. The totals given represent a relative fraction of actual vessel presence (Mintz 2012a).

Radiated noise from ships varies depending on the nature, size, and speed of the ship. The quietest Navy warships radiate much less broadband noise than a typical fishing vessel, while the loudest Navy ships during travel are almost on par with large oil tankers (Mintz and Filadelfo 2011c). McKenna et al. (2012b) determined that container ships produced broadband source levels around 188 dB re 1 μPa and a typical fishing vessel radiates noise at a source level of about 158 dB re 1 μPa (Mintz and Filadelfo 2011c; Richardson et al. 1995b; Urick 1983b). The average acoustic signature for a Navy vessel is 163 dB re 1 μPa, while the average acoustic signature for a commercial vessel is 175 dB re 1 μPa (Mintz and Filadelfo 2011c).

Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below about 50 Hz and by broadband components related to cavitation and flow noise at higher frequencies (approximately around the one-third octave band centered at 100 Hz) (Mintz and Filadelfo 2011c; Richardson et al. 1995b; Urick 1983b). Ship types also have unique acoustic signatures characterized by differences in dominant frequencies. Bulk carrier noise is predominantly near 100 Hz while container ship and tanker noise is predominantly below 40 Hz (McKenna et al. 2012b). Small craft types will emit higher-frequency noise (between 1 kHz and 50 kHz) than larger ships (below 1 kHz). Sound produced by vessels will typically increase with speed. During training and testing, speeds of most large naval vessels (greater than 60 ft) generally range from 10 to 15 knots. Ships will, on occasion, operate at higher speeds within their specific operational capabilities.

Anti-submarine warfare platforms (such as guided missile destroyers and cruisers) and submarines make up a large part of Navy traffic but are designed to be quiet to minimize detection. These platforms are much quieter than Navy oil tankers, for example, which have a smaller presence but contribute substantially more broadband noise than anti-submarine warfare platforms (Mintz and Filadelfo 2011c).

While commercial traffic (and, therefore, broadband noise generated by it) is relatively steady throughout the year, Navy traffic is episodic in the ocean. Vessels engaged in training and testing may consist of a single vessel involved in unit-level activity for a few hours or multiple vessels involved in a major training exercise that could last a few weeks within a given area. Activities involving vessel movements occur intermittently and are variable in duration. Navy vessels do contribute to the overall increased ambient noise in inshore waters near Navy ports, although their contribution to the overall noise in these environments is a small percentage compared to the large amounts of commercial and recreational vessel traffic in these areas (Mintz and Filadelfo 2011c).

6.1.2 Aircraft Overflight Noise

Fixed-wing, tiltrotor, and rotary-wing aircraft are used for a variety of training and testing activities throughout the action area, contributing both airborne and underwater sound to the ocean environment. Aircraft used in training and testing generally have turboprop or jet engines. Motors, propellers, and rotors produce the most noise, with some noise contributed by aerodynamic turbulence. Aircraft sounds have more energy at lower frequencies. Aircraft may transit to or from vessels at sea throughout the action area from established airfields on land. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Table 44 provides source levels for some typical aircraft used during training and testing in the action area and depicts comparable airborne source levels for the F-35A, EA-18G, and F/A-18C/D during takeoff.

Table 44. Representative aircraft sound characteristics (Navy 2017a).

Noise Source	Sound Pressure Level
In-Water	
F/A-18 Subsonic at 1,000 ft. Altitude	152 dB re 1 μPa at 2 m below water surface[1]
F/A-18 Subsonic at 10,000 ft. Altitude	128 dB re 1 μPa at 2 m below water surface[1]
H-60 Helicopter Hovering at 82 ft. Altitude	Approximately 125 dB re 1 μPa at 1 m below water surface[*]
Airborne	
Jet Aircraft Under Military Power	144 dBA re 20 μPa at 15 m from source[2]
Jet Aircraft Under Afterburner	148 dBA re 20 μPa at 15 m from source[2]
H-60 Helicopter Hovering at 50 ft. AGL	113 dBA re 20 μPa at 25 m from source[2]
F-35A Takeoff Through 500 ft. AGL	119 dBA re 20 μPa[3]

[*] Estimate based on in-air level
Notes: dB re 1 μPa = decibel(s) referenced to 1 micropascal, dBA re 20 μPa = A-weighted decibel(s) referenced to 20 microPascal, ft = feet, m = meter(s), AGL = Above Ground Level
Sources: [1]Eller and Cavanagh (2000), [2]Bousman and Kufeld (2005), [3]U.S. Department of the Air Force (2016)

Sound generated in air is transmitted to water primarily in a narrow area directly below the source. A sound wave propagating from any source must enter the water at an angle of incidence of about 13 degrees or less from the vertical for the wave to continue propagating under the water's surface. At greater angles of incidence, the water surface acts as an effective reflector of the sound wave and allows very little penetration of the wave below the water (Urick 1983a). Water depth and bottom conditions strongly influence how the sound from airborne sources propagates underwater. At lower altitudes, sound levels reaching the water surface would be higher, but the transmission area would be smaller (i.e., sound would radiate out as a cone from the aircraft, with the area of transmission at the water surface being larger at increasing distances). As the sound source gains altitude, sound reaching the water surface diminishes, but the possible transmission area increases. Estimates of underwater sound pressure level are provided for representative aircraft in Table 44.

Fixed-wing aircraft

Noise generated by fixed-wing aircraft is transient in nature and extremely variable in intensity. Most fixed-wing aircraft sorties (a flight mission made by an individual aircraft) would occur above 3,000 ft Air combat maneuver altitudes generally range from 5,000 to 30,000 ft, and typical airspeeds range from very low (less than 100 knots) to high subsonic (less than 600 knots). Sound exposure levels at the sea surface from most air combat maneuver overflights are expected to be less than 85 A-weighted dBs (based on an F/A-18 aircraft flying at an altitude of 5,000 ft and at a subsonic airspeed (400 knots; Navy 2017a). Exposure to fixed-wing aircraft noise in water would be brief (seconds) as an aircraft quickly passes overhead.

Helicopters

The underwater noise produced by helicopters is estimated to be 125 dB re 1 μPa at 1 meter (m) below water surface for an UH-60 hovering at 82 ft (25 m) altitude (Kufeld and M. 2005). Helicopter unit level training typically entails single-aircraft sorties over water that start and end at an air station, although flights may occur from ships at sea. Individual flights typically last about two to four hours. Some events require low-altitude flights over a defined area, such as mine countermeasure activities deploying towed systems. Most helicopter sorties associated with mine countermeasures would occur at altitudes as low as 75 to 100 ft. Likewise, in some anti-submarine warfare events, a dipping sonar is deployed from a line suspended from a helicopter hovering at low altitudes over the water.

Sonic Booms

An intense but infrequent type of aircraft noise is the sonic boom, produced when an aircraft exceeds the speed of sound. Supersonic aircraft flights are not intentionally generated below 30,000 ft unless over water and more than 30 NM from inhabited coastal areas or islands, though deviation from these guidelines may occur for tactical missions that require supersonic flight, phases of formal training requiring supersonic speeds, research and test flights that require supersonic speeds, and for flight demonstration purposes when authorized by the Chief of Naval Operations. A supersonic test track parallel to the Eastern Shore of the Delmarva Peninsula has historically been used by the U.S. Navy and is regularly used for F/A-18 and F-35 sorties. Due to the proximity of the supersonic test track to the Eastern Shore of the Delmarva Peninsula, sonic booms may occur closer to shore within the test track.

Several factors that influence sonic booms include weight, size, and shape of aircraft or vehicle; altitude; flight paths; and atmospheric conditions. A larger and heavier aircraft must displace more air and create more lift to sustain flight, compared with small, light aircraft Therefore, larger aircraft create sonic booms that are stronger than those of smaller, lighter aircraft. Consequently, the larger and heavier the aircraft, the stronger the shock waves (Navy 2017a). Aircraft maneuvers that result in changes to acceleration, flight path angle, or heading can also affect the strength of a boom. In general, an increase in flight path angle (lifting the aircraft's nose) will diffuse a boom while a decrease (lowering the aircraft's nose) will focus it. In addition, acceleration will focus a boom while deceleration will weaken it. Any change in horizontal direction will focus or intensify a boom by causing two or more wave fronts that originated from the aircraft at different times to coincide exactly (Navy 2017a). Atmospheric conditions such as wind speed and direction, and air temperature and pressure can also influence the sound propagation of a sonic boom.

Of all the factors influencing sonic booms, increasing altitude is the most effective method of reducing the sonic boom intensity that is experienced at the sea or shore level. The width of the boom "carpet" or area exposed to a sonic boom beneath an aircraft is about 1 mile for each 1,000 ft of altitude. For example, an aircraft flying supersonic, straight, and level at 50,000 ft can produce a sonic boom carpet about 50 miles wide. The sonic boom, however, would not be uniform, and its intensity at the water surface would decrease with greater aircraft altitude. Maximum intensity is directly beneath the aircraft and decreases as the lateral distance from the flight path increases until shock waves refract away from the ground or water surface and the sonic boom attenuates. The lateral spreading of the sonic boom depends only on altitude, speed, and the atmosphere and is independent of the vehicle's shape, size, and weight. The ratio of the aircraft length to maximum cross-sectional area also influences the intensity of the sonic boom. The longer and more slender the aircraft, the weaker the shock waves. The wider and more blunt the aircraft, the stronger the shock waves can be (Navy 2017a).

In air, the energy from a sonic boom is concentrated in the frequency range from 0.1 to 100 Hz. The underwater sound field due to transmitted sonic boom waveforms is primarily composed of low-frequency components (Sparrow 2002), and frequencies greater than 20 Hz have been found to be difficult to observe at depths greater than 33 ft (10 m) (Sohn et al. 2000). F/A-18 Hornet supersonic flight was modeled to obtain peak sound pressure levels and energy flux density at the water surface and at depth (Laney and Cavanagh 2000). These results are shown in Table 45.

Table 45. Sonic boom underwater sound levels modeled for F/A-18 Hornet supersonic flight (Navy 2017a).

Mach Number*	Aircraft Altitude (km)	Peak SPL (dB re 1 µPa)			Energy Flux Density (dB re 1 µPa²-s)[1]		
		At surface	50 m Depth	100 m Depth	At surface	50 m Depth	100 m Depth
1.2	1	176	138	126	160	131	122
	5	164	132	121	150	126	117
	10	158	130	119	144	124	115
2	1	178	146	134	161	137	128
	5	166	139	128	150	131	122
	10	159	135	124	144	127	119

[1] Equivalent to SEL for a plane wave.

** Mach number equals aircraft speed divided by the speed of sound.*

Notes: SPL = sound pressure level, dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 1 µPa²-s = decibel(s) referenced to 1 micropascal squared seconds, m = meter(s), km = kilometers

6.1.3 Sonar and other Transducers

Active sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. The Navy employs a variety of sonars and other transducers to obtain and transmit information about the undersea environment. Some examples are mid-frequency hull-mounted sonars used to find and track submarines; high-frequency small object detection sonars used to detect mines; high-frequency underwater modems used to transfer data over short ranges; and extremely high-frequency (greater than 200 kHz) Doppler sonars used for navigation, like those used on commercial and private vessels. The characteristics of these sonars and other transducers, such as source level, beam width, directivity, and frequency, depend on the purpose of the source. Higher frequencies can carry more information or provide more information about objects off which they reflect, but attenuate more rapidly. Lower frequencies attenuate less rapidly, so may detect objects over a longer distance, but with less detail.

Propagation of sound produced underwater is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity. The sound received at a particular location will be different than near the source due to the interaction of many factors including propagation loss; how the sound is reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher-frequency sounds propagate. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its exposure analysis that consider sound source characteristics and varying ocean conditions across the action area. The Navy's acoustic modeling approach is described further in Section 2.2 of this opinion and in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts on Marine Mammals and Sea Turtles* (Navy 2018b).

For its acoustic exposure analysis, the Navy grouped sonars and other transducers into classes that share an attribute, such as frequency range or purpose of use. Classes are further sorted by bins based on the frequency or bandwidth; source level; and, when warranted, the application in which the source would be used, as follows:

- frequency of the non-impulsive acoustic source
    - low-frequency sources operate below 1 kHz
    - mid-frequency sources operate at and above 1 kHz, up to and including 10 kHz
    - high-frequency sources operate above 10 kHz, up to and including 100 kHz
    - very high-frequency sources operate above 100 kHz but below 200 kHz
- sound pressure level
    - greater than 160 dB re 1 μPa, but less than 180 dB re 1 μPa
    - equal to 180 dB re 1 μPa and up to 200 dB re 1 μPa
    - greater than 200 dB re 1 μPa
- application in which the source would be used.
    - sources with similar functions that have similar characteristics, such as pulse length (duration of each pulse), beam pattern, and duty cycle

The bins used for classifying active sonars and transducers that are quantitatively analyzed in the action area are shown in Table 46. While general parameters or source characteristics are shown in the table, actual source parameters are classified. Table 46 shows the bin use that could occur in any year for training and testing activities. A range of annual bin use indicates that use of that bin is anticipated to vary annually, consistent with the variation in the number of annual activities described in Section 3.3.

Table 46. Sonar and transducer sources quantitatively analyzed (Navy 2017a).

Source Class Category	Bin	Description	Unit[1]	Training		Testing	
				Annual[2]	5-year Total	Annual[2]	5-year Total
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF3	LF sources greater than 200 dB	H	0	0	1,308	6,540
	LF4	LF sources equal to 180 dB and up to 200 dB	H	0	0	971	4,855
			C	0	0	20	100
	LF5	LF sources less than 180 dB	H	9	43	1,752	8,760
	LF6	LF sources greater than 200 dB with long pulse lengths	H	145 – 175	784	40	200
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-61)	H	5,005 – 5,605	26,224	3,337	16,684
	MF1K	Kingfisher mode associated with MF1 sonars	H	117	585	152	760
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	2,078 – 2,097	10,428	1,257	6,271
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22)	H	591 – 611	2,994	370 – 803	2,624
	MF5	Active acoustic sonobuoys (e.g., DICASS)	C	6,708–6,836	33,796	5,070 – 6,182	27,412
	MF6	Active underwater sound signal devices (e.g., MK 84)	C	0	0	1,256 – 1,341	6,390
	MF8	Active sources (greater than 200 dB) not otherwise binned	H	0	0	348	1,740
	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	0	0	7,395–7,562	37,173

Source Class Category	Bin	Description	Unit[1]	Training		Testing	
				Annual[2]	5-year Total	Annual[2]	5-year Total
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz (continued)	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	H	870	4,348	5,690	28,450
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%	H	873 – 1,001	4,621	1,424	7,120
	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%	H	367 – 397	1,894	1,388	6,940
	MF14	Oceanographic MF sonar	H	0	0	1,440	7,200
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	1,928 – 1,932	9,646	397	1,979
	HF3	Other hull-mounted submarine sonars (classified)	H	0	0	31	154
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)	H	5,411 – 6,371	29,935	30,772 – 30,828	117,916
	HF5	Active sources (greater than 200 dB) not otherwise binned	H	0	0	1,864 – 2,056	9,704
			C	0	0	40	200
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	0	0	2,193	10,868
	HF7	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	H	0	0	1,224	6,120
	HF8	Hull-mounted surface ship sonars (e.g., AN/SQS-61)	H	20	100	2,084	10,419
Very High Frequency Sonars (VHF): Non-	VHF1	Very high frequency sources	H	0	0	12	60

Source Class Category	Bin	Description	Unit[1]	Training		Testing	
				Annual[2]	5-year Total	Annual[2]	5-year Total
tactical sources that produce signals between 100 and 200 kHz		greater than 200 dB					
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	MF systems operating above 200 dB	H	582 – 641	3,028	820	4,100
	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)	C	1,476 – 1,556	7,540	4,756 – 5,606	25,480
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	H	4,485 – 5,445	24,345	2,941– 3,325	15,472
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK 3)	C	425 – 431	2,137	3,493	17,057
	ASW5[3]	MF sonobuoys with high duty cycles	H	572 – 652	3,020	608 – 628	3,080
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK-46, MK-54, or Anti-Torpedo Torpedo)	C	57	285	806 – 980	4,336
	TORP2	Heavyweight torpedo (e.g., MK-48)	C	80	400	344 – 408	1,848
	TORP 3	Heavyweight torpedo (e.g., MK 48)	C	0	0	100	440
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	HF sources with short pulse lengths, narrow beam widths, and focused beam patterns	H	0	0	1,224	6,120
Acoustic Modems (M): Systems used to transmit data through the water	M3	MF acoustic modems (greater than 190 dB)	H	0	0	634	3,169

Source Class Category	Bin	Description	Unit[1]	Training		Testing	
				Annual[2]	5-year Total	Annual[2]	5-year Total
Swimmer Detection Sonars (SD): Systems used to detect divers and submerged *swimmers*	SD1 – SD2	HF and VHF sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security	H	0	0	176	880
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	MF SAS systems	H	0	0	960	4,800
	SAS2	HF SAS systems	H	0 – 8,400	25,200	3,512	17,560
	SAS3	VHF SAS systems	H	0	0	960	4,800
	SAS4	MF to HF broadband mine countermeasure sonar	H	0	0	960	4,800
Broadband Sound Sources (BB): Sonar systems with large frequency spectra, used for various purposes	BB1	MF to HF mine countermeasure sonar	H	0	0	960	4,800
	BB2	HF to VHF mine countermeasure sonar	H	0	0	960	4,800
	BB4	LF to MF oceanographic source	H	0	0	876 – 3,252	6,756
Broadband Sound Sources (BB) (continued): Sonar systems with large frequency spectra, used for various purposes	BB5	LF to MF oceanographic source	H	0	0	672	3,360
	BB6	HF oceanographic source	H	0	0	672	3,360
	BB7	LF oceanographic source	C	0	0	120	600

[1] H = hours; C = count (e.g., number of individual pings or individual sonobuoys).

[2] Expected annual use may vary per bin because the number of events may vary from year to year, as described in Section 3.3.

In addition to the sources described above that were quantitatively analyzed for potential exposure to ESA-listed marine mammals and sea turtles, the Navy utilizes in-water active acoustic sources with narrow beam widths, downward directed transmissions, short pulse lengths, frequencies above known hearing ranges, low source levels, or combinations of these factors. The Navy categorizes these sources as *de minimis* sources and did not quantitatively analyze them for potential exposure to marine mammals or sea turtles. When used during routine training and testing activities, and in a typical environment, *de minimis* sources fall into one or more of the following categories:

- Transmit primarily above 200 kHz: Sources above 200 kHz are above the hearing range of the most sensitive marine mammals and far above the hearing range of any other animals in the action area.
- Source levels of 160 dB re 1 µPa or less: Low-powered sources with source levels less than 160 dB re 1 µPa are typically hand-held sonars, range pingers, transponders, and acoustic communication devices. Assuming spherical spreading for a 160 dB re 1 µPa source, the sound will attenuate to less than 140 dB within 10 m and less than 120 dB within 100 m of the source. Ranges would be even shorter for a source less than 160 dB re 1 µPa source level.
- Acoustic source classes listed in Table 47: Sources with operational characteristics, such as short pulse length, narrow beam width, downward-directed beam, and low energy release, or manner of system operation which minimize the possibility of impacting protected species (actual source parameters listed in the classified bin list).

Table 47. Sonars and transduces used, but not quantitatively analyzed for exposure to protected species (Navy 2017a).

Source Class Category	Bin	Characteristics
Broadband Sound Sources (BB): Sources with wide frequency spectra	BB3	• Very high frequency • Very short pulse length
	BB8	• Small imploding source (lightbulb)
Doppler Sonar/Speed Logs (DS): High-frequency/very high-frequency navigation transducers	DS2–DS4	*Required for safe navigation.* • downward focused • narrow beam width • very short pulse lengths
Fathometers (FA): High-frequency sources used to determine water depth	FA1–FA4	*Required for safe navigation*. • downward focused directly below the vessel • narrow beam width (typically much less than 30°) • short pulse lengths (less than 10 milliseconds)
Hand-Held Sonar (HHS): High-frequency sonar devices used by Navy divers for object location	HHS1	• very high frequency sound at low power levels • narrow beam width • short pulse lengths • under positive control of the diver (power and direction)
Imaging Sonar (IMS): Sonars with high or very high frequencies used obtain images of objects underwater	IMS1-IMS3	• High-frequency or very high-frequency • downward directed • narrow beam width • very short pulse lengths (typically 20 milliseconds)
High-Frequency Acoustic Modems (M): Systems that send data underwater **Tracking Pingers (P):** Devices that send a ping to identify an object location	M2 P1-P4	• low duty cycles (single pings in some cases) • short pulse lengths (typically 20 milliseconds) • low source levels
Acoustic Releases (R): Systems that ping to release a bottom-mounted object from its housing in order to retrieve the device at the surface	R1-R3	• typically emit only several pings to send release order
Side-Scan Sonars (SSS): Sonars that use active acoustic signals to produce high-resolution images of the seafloor	SSS1-SSS2	• downward-directed beam • short pulse lengths (less than 20 milliseconds)

Notes: ° = degree(s), kHz = kilohertz, lb. = pound(s)

6.1.4 Noise from Weapons

The Navy trains and tests using a variety of weapons. Depending on the weapon, noise may be produced at launch or firing; while in flight; or upon impact. Other devices intentionally produce noise to serve as a non-lethal deterrent. Not all weapons utilize explosives, either by design or because they are non-explosive practice munitions. Noise produced by explosives, both in air and water, are discussed in Section 6.1.5. Examples of some types of weapons noise are shown in Table 48.

Table 48. Examples of noise from weapons (Navy 2017a).

Noise Source	Sound Level
In-Water Noise Level	
Naval Gunfire Muzzle Blast (5-inch)	Approximately 200 dB re 1 μPa peak directly under gun muzzle at 1.5 m below the water surface[1]
Airborne Noise Level	
Naval Gunfire Muzzle Blast (5-inch)	178 dB re 20 μPa peak directly below the gun muzzle above the water surface[1]
Hellfire Missile Launch from Aircraft	149 dB re 20 μPa at 4.5 m[2]
Advanced Gun System Missile (115-millimeter)	133-143 dBA re 20 μPa between 12 and 22 m from the launcher on shore[3]
RIM 116 Surface-to-Air Missile	122-135 dBA re 20 μPa between 2 and 4 m from the launcher on shore[3]
Tactical Tomahawk Cruise Missile	92 dBA re 20 μPa 529 m from the launcher on shore[3]

Sources: [1]Yagla and Stiegler (2003a); [2]U.S. Department of the Army (1999); [3]U.S. Department of the Navy (2013).

Notes: dB re 1 μPa = decibel(s) referenced to 1 micropascal, dB re 20 μPa = decibel(s) referenced to 20 micropascals, dBA re 20 μPa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s)

Muzzle Blast from Naval Gunfire

Firing a gun produces a muzzle blast in air that propagates away from the gun with strongest directivity in the direction of fire. As the pressure from the muzzle blast from a ship-mounted large caliber gun propagates in air toward the water surface, the pressure can be both reflected from the water surface and transmitted into the water. As explained in Appendix D (Acoustic and Explosive Concepts) in the AFTT DEIS/OEIS (Navy 2017c), most sound enters the water in a narrow cone beneath the sound source (within about 13 to 14 degrees of vertical), with most sound outside of this cone being totally reflected from the water surface. In-water sound levels were measured during the muzzle blast of a 5 inch large caliber naval gun. The highest possible sound level in the water (average peak SPL of 200 dB re 1 μPa, measured 5 ft below the surface) was obtained when the gun was fired at the lowest angle, placing the blast closest to the water surface (Yagla and Stiegler 2003b). The unweighted sound exposure level would be expected to be 15 to 20 dB lower than the peak pressure, making the highest possible sound exposure level in the water about 180 to 185 dB re 1 μPa^2-s directly below the muzzle blast. Other gunfire arrangements, such as with smaller-caliber weapons or greater angles of fire, would result in less sound entering the water. The sound entering the water would have the strongest directivity directly downward beneath the gun blast, with lower sound pressures at increasing angles of incidence until the angle of incidence is reached where no sound enters the water.

Supersonic Projectile Bow Shock Wave

Supersonic projectiles, such as a fired gun shell or kinetic energy weapon, create a bow shock wave along the line of fire. A bow shock wave is an impulsive sound caused by a projectile exceeding the speed of sound (for more explanation, see Appendix D [Acoustic and Explosive Concepts] in the AFTT DEIS/OEIS (Navy 2017c). The bow shock wave itself travels at the speed of sound in air. The projectile bow shock wave created in air by a shell in flight at supersonic speeds propagates in a cone (generally about 65 degrees) behind the projectile in the direction of fire (Pater 1981). Like sound from the gun muzzle blast, sound waves from a projectile in flight could only enter the water in a narrow cone beneath the sound source, with in-air sound being totally reflected from the water surface outside of the cone. The region of underwater sound influence from a single traveling shell would be relatively narrow, and the duration of sound influence would be brief at any location.

Launch Noise

Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket. It rapidly fades as the missile or target reaches optimal thrust conditions and the missile or target reaches a downrange distance where the booster burns out and the sustainer engine continues. Examples of launch noise sound levels are shown in Table 48.

Impact Noise (Non-explosive)

Any object dropped in the water would create a noise upon impact, depending on the object's size, mass, and speed. Sounds of this type are produced by the kinetic energy transfer of the object with the target surface and are highly localized to the area of disturbance. A significant portion of an object's kinetic energy would be lost to splash, any deformation of the object, and other forms of non-mechanical energy (Mclennan 1997). The remaining energy could contribute to sound generation. Most objects would be only momentarily detectable, but some large objects traveling at high speeds could generate a broadband impulsive sound upon impact with the water surface. Sound associated with impact events is typically of low frequency (less than 250 Hz) and of short duration.

Long Range Acoustic Device

Although not a weapon, the Long Range Acoustic Device (and other hailing and deterrent sources) is considered along with in-air sounds produced by Navy sources. The Long Range Acoustic Device is a communication device that can be used to warn vessels from continuing towards a high value asset by emitting loud sounds in air. The system would typically be used in training activities near shore, and use would be intermittent during these activities. Source levels at 1 m range between 137 dBA re 1 μPa for small portable systems and 153 dBA re 1 μPa for large systems. Sound would be directed within a 30 to 60° wide zone and would be directed over open water.

6.1.5 Air Guns

Air guns are essentially stainless steel tubes charged with high-pressure air via a compressor. An impulsive sound is generated when the air is almost instantaneously released into the surrounding water. Small air guns with capacities up to 60 in^3 would be used during testing activities in various offshore areas in the action area, as well as near shore at Newport, Rhode Island. Table 49 shows the number of air guns shots proposed in the action area.

Table 49. Air gun sources proposed for use in the action area (Navy 2017a).

Source Class Category	Bin	Unit[1]	Training		Testing	
			Annual	5-year Total	Annual	5-year Total
Air Guns (AG): Small underwater air guns	AG	C	0	0	604	3,020

Generated impulses would have short durations, typically a few hundred milliseconds, with dominant frequencies below 1 kHz. The rms SPL and peak pressure (SPL peak) at a distance 1 m from the air gun would be approximately 215 dB rms re 1 μPa and 227 dB_{peak} re 1 μPa, respectively, if operated at the full capacity of 60 cubic inches. The size of the air gun chamber can be adjusted, which would result in a lower SPL and SEL per shot.

6.1.6 Pile Driving

Impact pile driving and vibratory pile removal would occur during construction of an Elevated Causeway System, a temporary pier that allows the offloading of ships in areas without a permanent port. Construction of the elevated causeway could occur in sandy shallow water coastal areas at 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 (Figure 9).

Installing piles for elevated causeways would involve the use of an impact hammer mechanism with both it and the pile held in place by a crane. The hammer rests on the pile, and the assemblage is then placed in position vertically on the beach or, when offshore, positioned with the pile in the water and resting on the seafloor. When the pile driving starts, the hammer part of the mechanism is raised up and allowed to fall, transferring energy to the top of the pile. The pile is thereby driven into the sediment by a repeated series of these hammer blows. Each blow results in an impulsive sound emanating from the length of the pile radially and longitudinally, into the water column as well as from the bottom of the pile through the sediment. Because the impact wave travels through the steel pile at speeds faster than the speed of sound in water, a steep-fronted acoustic shock wave is formed in the water (Reinhall and Dahl 2011). An impact pile driver generally operates in the range of 35 to 50 strikes per minute.

Pile removal involves the use of vibratory extraction, during which the vibratory hammer is suspended from the crane and attached to the top of a pile. The pile is then vibrated by hydraulic motors rotating eccentric weights in the mechanism, causing a rapid up and down vibration in the pile. This vibration causes the sediment particles in contact with the pile to lose frictional grip on the pile. The crane slowly lifts up on the vibratory driver and pile until the pile is free of the sediment. Vibratory removal creates continuous non-impulsive noise at low source levels for a short duration.

Pile driving for elevated causeway system training would occur in shallower water, and sound could be transmitted on direct paths through the water, be reflected at the water surface or bottom, or travel through bottom substrate. Soft substrates such as sand bottom at the proposed elevated causeway system locations would absorb or attenuate the sound more readily than hard substrates (rock), which may reflect the acoustic wave. Most acoustic energy would be concentrated below 1,000 Hz (Caltrans 2012; Hildebrand 2009a).

The source levels of the noise produced by impact pile driving and vibratory pile removal from an actual elevated causeway installation pile driving and removal are shown in Table 50.

Table 50. Underwater sound levels for elevated causeway system pile driving and removal (Navy 2017a).

Pile Size and Type	Method	Average Sound Levels at 10 m (SEL per individual pile)
24-in. Steel Pipe Pile	Impact[1]	192 dB re 1 μPa SPL rms 182 dB re 1 μPa²s SEL (single strike) 211 dB re 1 μPa SPL peak[17]
24-in. Steel Pipe Pile	Vibratory[2]	146 dB re 1 μPa SPL rms 145 dB re 1 μPa²s SEL (per second of duration)

[1] Illingworth and Rodkin (2016), [2] Illingworth and Rodkin (2015)
Notes: in. = inch, SEL = Sound Exposure Level, SPL = Sound Pressure Level, rms = root mean squared, dB re 1 μPa = decibels referenced to 1 micropascal

During this training activity, the length of the pier, and therefore the number of piles required, would be determined by the distance from shore to the appropriate water depth for ship off-loading. For the purposes of training activities, a pier length of 1,500 ft (457 m) is typical, with approximately 119 supporting piles. Construction of the Elevated Causeway System would involve intermittent impact pile driving over approximately 20 days. Crews work 24 hours a day and would drive approximately six piles in that period. Each pile takes about 15 minutes to drive with time taken between piles to reposition the driver. When training events that use the Elevated Causeway System are complete, the structure would be removed using vibratory methods over

[17] The Navy reported the minimum range of rms values (192) incorrectly as the peak SPL in their BA and EIS. NMFS obtained a copy of the original monitoring report and took the average of the reported peak values (which is 211 dB re 1 μPa SPL peak) indicated in the table, but kept the lowest reported rms value as provided by the Navy which is similar to other rms values for the size and type of piles used here.

approximately 10 days. Crews would remove about 12 piles per 24-hour period, each taking about six minutes to remove. Table 51 summarizes the pile driving and pile removal activities that would occur during a 24-hour period.

Table 51. Summary of pile driving and removal activities per 24-hour period (Navy 2017a).

Method	Piles Per 24-Hour Period	Time Per Pile	Total Estimated Time of Noise Per 24-Hour Period
Pile Driving (Impact)	6	15 minutes	90 minutes
Pile Removal (Vibratory)	12	6 minutes	72 minutes

6.2 Explosive Stressors

This section describes the characteristics of explosions during naval training and testing. The activities analyzed in this opinion that use explosives are described in Section 3 of this opinion and in Appendix A (Navy Activity Descriptions) in the AFTT DEIS/OEIS (Navy 2017c). The near-instantaneous rise from ambient to an extremely high peak pressure is what makes an explosive shock wave potentially damaging. Farther from an explosive, the peak pressures decay and the explosive waves propagate as an impulsive, broadband sound. Several parameters influence the effect of an explosive: the weight of the explosive warhead, the type of explosive material, the boundaries and characteristics of the propagation medium, and, in water, the detonation depth. The net explosive weight, the explosive power of a charge expressed as the equivalent weight of trinitrotoluene, accounts for the first two parameters.

6.2.1 Explosions in Water

Explosive detonations during training and testing activities are associated with high-explosive munitions, including, but not limited to, bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could be detonated in the water column or on the ocean bottom. Most detonations would occur in waters greater than 200 ft in depth, and greater than 3 NM from shore, although mine warfare, demolition, and some testing detonations would occur in shallow water close to shore.

Explosives detonated in water are binned by net explosive weight. The bins of explosives that are proposed for use in the action area are shown in Table 52. This table shows the number of in-water explosive items that could be used in any year for training and testing activities. A range of annual bin use indicates that use of that bin is anticipated to vary annually, consistent with the variation in the number of annual activities described in Section 3.3 of this opinion. The five-year total takes any annual variability into account.

Table 52. Explosive sources quantitatively analyzed that could be used underwater or at the water surface (Navy 2017a).

Bin	Net Explosive Weight[1] (lb.)	Example Explosive Source	Training		Testing	
			Annual[2]	5-year Total	Annual[2]	5-year Total
E1	0.1–0.25	Medium-caliber projectile	7,700	38,500	17,840 – 26,840	116,200
E2	> 0.25–0.5	Medium-caliber projectile	210 – 214	1,062	0	0
E3	> 0.5–2.5	Large-caliber projectile	4,592	22,960	3,054 – 3,422	16,206
E4	> 2.5–5	Mine neutralization charge	127 – 133	653	746 – 800	3,784
E5	> 5–10	5 inch projectile	1,436	7,180	1,325	6,625
E6	> 10–20	Hellfire missile	602	3,010	28 – 48	200
E7	> 20–60	Demo block/ shaped charge	4	20	0	0
E8	> 60–100	Lightweight torpedo	22	110	33	165
E9	> 100–250	500 pound bomb	66	330	4	20
E10	> 250–500	Harpoon missile	90	450	68–98	400
E11	> 500–650	650 pound mine	1	5	10	50
E12	> 650–1,000	2,000 pound bomb	18	90	0	0
E16[4]	> 7,250–14,500	Littoral Combat Ship full ship shock trial	0	0	0–12	12
E17[4]	> 14,500–58,000	Aircraft carrier full ship shock trial	0	0	0–4	4

[1] Net Explosive Weight refers to the equivalent amount of trinitrotoluene the actual weight of a munition may be larger due to other components.

[2] Expected annual use may vary per bin because the number of events may vary from year to year, as described in Chapter 2, Description of Proposed Action and Alternatives.

[3] E14 is not modeled for protected species impacts in water because most energy is lost into the air or to the bottom substrate due to detonation in very shallow water.

[4] Shock trials consist of four explosions each. In any given year there could be 0-3 small ship shock trials (E16) and 0-1 large ship shock trials (E17). Over a 5-year period, there could be three small ship shock trials (E16) and one large ship shock trial (E17).

In addition to the explosives quantitatively analyzed for impacts to ESA-listed species shown in Table 52, the Navy uses some very small impulsive sources (less than 0.1 pound net explosive weight), categorized in bin E0, that were not quantitatively analyzed by the Navy for potential exposure to protected species. Quantitative modeling in multiple locations has indicated that these sources have a very small zone of influence. For this reason, they are excluded from further consideration in this opinion.

Propagation of explosive pressure waves in water is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity, which affect how the pressure waves are reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher frequency components of explosive broadband noise can propagate. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its exposure analysis that consider sound source characteristics and varying ocean conditions across the action area. The Navy's acoustic modeling approach is described further in Section 2.2 of this opinion and in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts on Marine Mammals and Sea Turtles* (Navy 2018b).

6.2.2 Explosions in Air

Explosions in air include detonations of projectiles and missiles during surface-to-air gunnery and air-to-air missile exercises conducted during air warfare. These explosions typically occur far above the water surface. Various missiles, rockets, and medium and large projectiles may be explosive or non-explosive, depending on the objective of the training or testing activity in which they are used. Bombs and projectiles that detonate at or near the water surface, which are considered for underwater impacts, would also release some explosive energy into the air.

In air, the propagation of impulsive noise from an explosion is highly influenced by atmospheric conditions, including temperature and wind. While basic estimation methods do not consider the unique environmental conditions that may be present on a given day, they allow for approximation of explosive energy propagation under neutral atmospheric conditions. Explosions that occur during air warfare would typically be at sufficient altitude that a large portion of the sound refracts upward due to cooling temperatures with increased altitude and would not reach the water's surface where ESA-listed species could occur.

Missiles, rockets, projectiles, and other cased weapons will produce casing fragments upon detonation. These fragments may be of variable size and are ejected at supersonic speed from the detonation.

6.3 Energy Stressors

Energy stressors include in-water electromagnetic devices, in-air electromagnetic devices, and lasers, each of which is described further in the sections below.

6.3.1 In-Water Electromagnetic Devices

In-water electromagnetic energy devices include towed or unmanned mine warfare systems that simply mimic the electromagnetic signature of a vessel passing through the water. None of the devices include any type of electromagnetic "pulse." A mine neutralization device could be towed through the water by a surface vessel or remotely operated vehicle, emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. The sound and electromagnetic signature cause nearby mines to detonate.

Generally, voltage used to power these systems is around 30 volts. Since saltwater is an excellent conductor, just 35 volts (capped at 55 volts) is required to generate the current needed to power the systems. These are considered safe levels for marine species due to the low electric charge relative to salt water (Navy 2017a).

The static magnetic field generated by the mine neutralization devices is of relatively minute strength. Typically, the maximum magnetic field generated would be approximately 2,300 microteslas[18]. This level of electromagnetic density is very low compared to magnetic fields generated by other everyday items (e.g., the magnetic field generated is between the levels of a refrigerator magnet, which is 15,000 to 20,000 microteslas).

6.3.2 In-Air Electromagnetic Devices

Sources of electromagnetic energy in the air include kinetic energy weapons, communications transmitters, radars, and electronic countermeasure transmitters. Electromagnetic devices on Navy platforms operate across a wide range of frequencies and power. On a single ship, the source frequencies may range from 2 megahertz to 14,500 megahertz, and transmitter maximum average power may range from 0.25 watts to 1,280,00 watts.

A radar system is an electromagnetic device that emits radio waves to detect and locate objects. In most cases, basic radar systems operate by generating pulses of radio frequency energy and transmitting these pulses via directional antennae into space (Courbis and Timmel, 2008). Some of this energy is reflected by the target back to the antenna, and the signal is processed to provide useful information to the operator.

Radars come in a variety of sizes and power, ranging from wide-band milliwatt systems to very high-power systems that are used primarily for long-range search and surveillance (Timmel et al. 2008). In general, radars operate at radio frequencies that range between 300 megahertz and 300 gigahertz, and are often classified according to their frequency range. Navy vessels commonly operate radar systems which include S-band and X-band electronically steered radar. S-band radar serves as the primary search and acquisition sensor capable of tracking and collecting data on a large number of objects while X-band radar can provide high resolution data on particular objects of interest and discrimination for weapons systems. Both systems employ a variety of waveforms and bandwidths to provide high quality data collection and operational flexibility (Baird et al. 2016a).

The Navy assumes that most platforms (e.g., vessels) associated with proposed training and testing activities will be transmitting from a variety of in-air electromagnetic devices at all times while they are underway, with very limited exceptions. Most of these transmissions (e.g., for routine surveillance, communications, and navigation) will be at low power. High-power settings are used for a small number of activities including ballistic missile defense training, missile and rocket testing, radar and other system testing, and signature analysis operations.

[18] The microtesla is a unit of measurement of magnetic flux density, or "magnetic induction."

6.3.3 Lasers

Low-energy lasers are used to illuminate or designate targets, to measure the distance to a target, to guide weapons, to aid in communication, and to detect or classify mines. High-energy lasers are used as weapons to create critical failures of air and surface targets.

6.4 Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors include vessels and other in-water devices, military expended materials, seafloor devices, and aircraft, each of which is described further in the sections below.

6.4.1 Vessels

Vessels used by the Navy during training and testing activities include ships (e.g., aircraft carriers, surface combatants), support craft, and submarines ranging in size from 15 ft to over 1,000 ft. Table 53 provides examples of the types of vessels, length, and speeds used in both testing and training activities.

Table 53. Representative vessel types, lengths, and speeds (Navy 2017a).

Type	Example(s)	Length	Typical Operating Speed
Aircraft Carrier	Aircraft Carrier (CVN)	>1000 ft.	10–15 knots
Surface Combatant	Cruisers (CG), Destroyers (DDG), Frigates (FF), Littoral Combat Ships (LCS)	300–700 ft.	10–15 knots
Amphibious Warfare Ship	Amphibious Assault Ship (LHA, LHD), Amphibious Transport Dock (LPD), Dock Landing Ship (LSD)	300–900 ft.	10–15 knots
Combat Logistics Force Ships	Fast Combat Support Ship (T-AOE), Dry Cargo/Ammunition Ship (T-AKE), Fleet Replenishment Oilers (T-AO)	600–750 ft.	8–12 knots
Support Craft/Other	Amphibious Assault Vehicle (AAV); Combat Rubber Raiding Craft (CRRC); Landing Craft, Mechanized (LCM); Landing Craft, Utility (LCU); Submarine Tenders (AS); Yard Patrol Craft (YP)	15–140 ft.	0–20 knots
Support Craft/Other—Specialized High Speed	High Speed Ferry/Catamaran; Patrol Combatants (PC); Rigid Hull Inflatable Boat (RHIB); Expeditionary Fast Transport (EPF); Landing Craft, Air Cushion (LCAC)	33–320 ft.	0–50+ knots
Submarines	Fleet Ballistic Missile Submarines (SSBN), Attack Submarines (SSN), Guided Missile Submarines (SSGN)	300–600 ft.	8–13 knots

Notes: > = greater than, m = meters, ft. = feet

Navy ships transit at speeds that are optimal for fuel conservation or to meet operational requirements. Large Navy ships (greater than 18 m in length) generally operate at average speeds of between 10 and 15 knots, and submarines generally operate at speeds in the range of 8 to 13 knots. Small craft (for purposes of this discussion, less than 50 ft in length), which are all support craft, have much more variable speeds (0 to 50+ knots, dependent on the mission). While these speeds are considered averages and representative of most events, some vessels need to operate outside of these parameters during certain situations. For example, to produce the required relative wind speed over the flight deck for take-off and landings, an aircraft carrier vessel group engaged in flight operations must adjust its speed through the water accordingly. Also, there are other instances such as launch and recovery of a small rigid hull inflatable boat; vessel boarding, search, and seizure training events; or retrieval of a target, when vessels would be idling or moving slowly ahead to maintain steerage. There are a few specific offshore events, including high-speed tests of newly constructed vessels, where vessels would operate at higher speeds. High speed movements of smaller craft during inshore operations could occur more frequently.

While the estimates provided in the tables below represent the average distribution of events, actual locations and hours of Navy vessel usage are dependent upon requirements, deployment schedules, annual budgets, and other unpredictable factors. Consequently, vessel use can be highly variable. Multiple activities usually occur from the same vessel, particularly in offshore waters, so increases in the number of activities do not necessarily result in increases in vessel use or transit. The Navy anticipates that manner in which the vessels are used to accomplish training and testing activities is likely to remain consistent with the range of variability observed over the last decade. Consequently, even with the addition of Undersea Warfare Training Range off the coast of Florida, the Navy does not expect an appreciable change in the levels, frequency, or locations where vessels have been used over the last decade (Navy 2017a).

The number of Navy vessels in the action area at any given time varies and is dependent on local training or testing requirements. Activities range from involving one or two vessels to several vessels operating over various time frames and locations. Vessel movements in the action area fall into one of two categories; (1) those activities that occur in the offshore component of the action area and (2) those activities that occur in inshore waters.

Activities that occur in the offshore component of the action area may last from a few hours to a few weeks. Vessels associated with those activities would be widely dispersed in the offshore waters, but more concentrated in portions of the action area in close proximity to ports, naval installations, range complexes, and testing ranges. In contrast, activities that occur in inshore waters can last from a few hours to up to 12 hours of daily movement per vessel per activity. The vessels operating within the inshore waters are generally smaller than those in the offshore waters.

In an attempt to determine traffic patterns for Navy and non-Navy vessels, the Center for Naval Analysis (Mintz and Parker 2006) conducted a review of historic data for commercial vessels, coastal shipping patterns, and Navy vessels. Commercial and non-Navy traffic, which included cargo vessels, bulk carriers, passenger vessels, and oil tankers (all over 20 m in length), was heaviest near the major shipping ports from the Gulf of Maine to southern Florida, as well as in specific international shipping lanes. Navy traffic was heaviest just offshore of Norfolk, Virginia, and Jacksonville, Florida, as well as along the coastal waters between the two ports.

As described further in Section 6.1.1, Navy vessel traffic is a relatively small component of overall vessel traffic in the action area. Table 54 shows the number and location of proposed activities that include the use of vessels in the action area. Each activity included in Table 54 could involve one or more vessels. The location and hours of Navy vessel usage for testing and training activities are most dependent upon the locations of Navy ports, piers, and established at-sea testing and training areas.

Table 54. Number and location of activities involving vessels (Navy 2017a).

Activity Area	Maximum Annual # of Activities	5-Year # of Activities
Training		
Northeast Range Complexes	411	2,055
Virginia Capes Range Complex	12,412	62,019
Navy Cherry Point Range Complex	6,754	33,693
Jacksonville Range Complex	10,841	54,112
Key West Range Complex	131	655
Gulf of Mexico Range Complex	771	3,855
Other AFTT Areas	691	3,435
Inshore Waters	**4,197**	**20,935**
Total	**36,028**	**180,759**
Testing		
Northeast Range Complexes	1,088	4,877
Virginia Capes Range Complex	1,784	7,388
Navy Cherry Point Range Complex	791	3,947
Jacksonville Range Complex	1,298	6,096
Key West Range Complex	398	1,732
Gulf of Mexico Range Complex	618	2,979
NUWC Newport Testing Range	767	3,830
SFOMF	198	992
NSWC Panama City Testing Range	406	2,003
Inshore Waters	**216**	**1078**
Total	**7,564**	**34,922**

Table 55 shows the number and location of proposed activities that include the use of vessels in the inshore waters of the action area. Each activity included in Table 55 and Table 56 could involve one or more vessels.

Table 55. Number and location of activities in inshore waters involving vessels (Navy 2017a).

Activity Area	Maximum Annual # of Activities	5-Year # of Activities
Training		
Boston, MA	2	6
Groton, CT	235	1,175
Narragansett, RI	198	990
Earle, NJ	2	6
Wilmington, DE	2	6
Delaware Bay, DE	2	6
James Rivers and Tributaries, VA	830	4,200
York River, VA	129	645
Lower Chesapeake Bay, VA	1,697	8,445
Hampton Roads, VA	4	12
Norfolk, VA	515	2,575
Morehead City, NC	2	6
Cooper River, SC	120	600
Savannah, GA	2	6
Kings Bay, GA	7	31
Mayport, FL	343	1,711
St. Johns River, FL	2	10
Port Canaveral, FL	47	231
Tampa, FL	2	6
St. Andrew Bay, FL	50	250
Beaumont, TX	4	12
Corpus Christi, TX	2	6
Total	**4,197**	**20,935**
Testing		
Bath, ME	11	55
Portsmouth, NH	26	130
Newport, RI	4	20
Groton, CT	9	47
Little Creek, VA	61	301
Norfolk, VA	64	318
Kings Bay, GA	4	20
Mayport, FL	27	135
Port Canaveral, FL	3	17
Pascagoula, MS	7	35
Total	**216**	**1,078**

As stated earlier, activities that include primarily small craft vessel movements in the inshore waters of the action area occur on a more regular basis than the offshore activities, and often involve the vessels traveling at speeds greater than 10 knots, and generally in more confined waterways than activities occurring in the offshore waters. In order to analyze this stressor, the number of hours of high speed vessel movement for small crafts in inshore waters are provided in Table 56.

Table 56. Number of high speed vessel hours for small crafts associated with training activities in inshore waters of the action area (Navy 2017a).

Activity Area	Maximum Annual # of High Speed Vessel Hours	5-Year # of High Speed Vessel Hours
Narragansett, RI	9,502	47,510
James Rivers and Tributaries	18,108	90,540
York River	6,590	32,950
Lower Chesapeake Bay	39,325	196,625
Cooper River, SC	12,651	63,255
Mayport, FL	510	2,550
St. Johns River	482	2,410
Port Canaveral, FL	4,352	21,760
St. Andrew Bay	56	280
Total	**91,576**	**457,880**

6.4.2 In-Water Devices

In-water devices include unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles, unmanned underwater vehicles, motorized autonomous targets, and towed devices. These devices are self-propelled and unmanned or towed through the water from a variety of platforms, including helicopters, unmanned underwater vehicles, and surface ships. In-water devices are generally smaller than most Navy vessels, ranging from several inches to about 50 ft. See Table 57 for information regarding the range of in-water devices to be used. These devices can operate anywhere from the water surface to the benthic zone. Most devices do not have a realistic potential to strike living marine resources because they either move slowly through the water column (e.g., most unmanned underwater vehicles) or are closely monitored by observers manning the towing platform who ensure the towed in-water device does not run into objects in the water.

Table 57. Representative types, sizes, and speeds of in-water devices (Navy 2017a).

Type	Example(s)	Length	Typical Operating Speed
Towed Device	Minehunting Sonar Systems; Improved Surface Tow Target; Towed Sonar System; MK-103, MK-104 and MK-105 Minesweeping Systems; Organic Airborne and Surface Influence Sweep	< 33 ft.	10–40 knots
Unmanned Surface Vehicle	MK-33 Seaborne Power Target Drone Boat, QST-35A Seaborne Powered Target, Ship Deployable Seaborne Target, Small Waterplane Area Twin Hull, Unmanned Influence Sweep System	< 50 ft.	Variable, up to 50+ knots
Unmanned Underwater Vehicle	Acoustic Mine Targeting System, Airborne Mine Neutralization System, AN/AQS Systems, Archerfish Common Neutralizer, Crawlers, CURV 21, Deep Drone 8000, Deep Submergence Rescue Vehicle, Gliders, Expendable Mobile Anti-Submarine Warfare Training Targets, Magnum Remotely Operated Vehicle, Manned Portables, MK 30 Anti-Submarine Warfare Targets, Remote Multi-Mission Vehicle, Remote Minehunting System, Large Displacement Unmanned Underwater Vehicle	< 60 ft.	1–15 knots
Torpedoes	Light-weight and Heavy-weight Torpedoes	< 33 ft.	20–30 knots

6.4.3 Military Expended Materials

Military expended materials that may cause physical disturbance or strike include: (1) all sizes of non-explosive practice munitions; (2) fragments from high explosive munitions; (3) expendable targets; and (4) expended materials other than munitions, such as sonobuoys or torpedo accessories.

6.4.4 Seafloor Devices

Seafloor devices represent items used during training or testing activities that are deployed onto the seafloor and recovered. These items include moored mine shapes, recoverable anchors, bottom-placed instruments, and robotic vehicles referred to as "crawlers." Seafloor devices are either stationary or move very slowly along the bottom.

6.5 Entanglement Stressors

The Navy proposes to utilize a variety of materials that could pose an entanglement risk to ESA-listed species including wires and cables, decelerators and parachutes, and biodegradable polymer.

6.5.1 Wires and Cables

Fiber optic cables are expended during Navy training and testing associated with remotely operated mine neutralization activities. Although a portion may be recovered, some fiber optic cables used during Navy training and testing associated with remotely operated mine neutralization activities would be expended. 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 millimeter) silica core and acylate coating, and looks and feels like thin monofilament fishing line. Other characteristics of tactical fiber are a 0.24 millimeter diameter, 12-pound tensile strength, and 3.4-millimeter bend radius (Navy 2017a). Tactical fiber is relatively brittle; it readily breaks if knotted, kinked, or abraded against a sharp object. Deployed tactical fiber will break if looped beyond its bend radius (3.4 millimeters), or exceeds its tensile strength (12 pound). If the fiber becomes looped around an underwater object or marine animal, it will 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 centimeters [cm] per second (Navy 2017a) where it would be susceptible to abrasion and burial by sedimentation.

Guidance wires are used during heavy-weight torpedo firings to help the firing platform control and steer the torpedo. They trail behind the torpedo as it moves through the water. The guidance wire is then released from both the firing platform and the torpedo, and sinks to the ocean floor. The torpedo guidance wire is a single-strand, thin gauge, coated copper alloy. The tensile breaking strength of the wire is a maximum of 40.4 pound (Swope and McDonald 2013), contrasting with the rope or lines associated with commercial fishing towed gear (trawls), stationary gear (traps), or entanglement gear (gillnets) that use ropes with substantially higher (up to 500 to 2,000 pound) breaking strength as their “weak links.” However, the guidance wire has a somewhat higher breaking strength than the monofilament used in the body of most commercial gillnets (typically 31 pound or less). The resistance to looping and coiling suggest that torpedo guidance wire does not have a high entanglement potential compared to other entanglement hazards (Swope and McDonald 2013). Torpedo guidance wire sinks at a rate of 0.24 m per second (Swope and McDonald 2013).

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 hollow rubber tubing or a bungee in a spiral configuration. The tensile breaking strength of the wire and rubber tubing is no more than 40 pounds. The length of the wire 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 the 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.

Bathythermographs are similar to sonobuoys in that they consist of an antenna, a float unit, and a subsurface unit (to measure temperature of the water column in the case of the bathythermograph) that is connected to the float unit by a wire. The bathythermograph wire is similar to the sonobuoy wire described above.

6.5.2 Decelerators and Parachutes

Decelerators/parachutes used during training and testing activities are classified into four different categories based on size: small, medium, large, and extra-large (Table 58). Aircraft-launched sonobuoys and lightweight torpedoes (such as the MK 46 and MK 54) use nylon decelerators/parachutes ranging in size from 18 to 48 in in diameter (small). The majority of the decelerators/parachutes in the small size category are smaller (18 in.) cruciform shape decelerators/parachutes associated with sonobuoys. Illumination flares use medium-sized decelerators/parachutes, up to approximately 19 ft in diameter. Both small- and medium-sized decelerators/parachutes are made of cloth and nylon, many with weights on their short attachment lines to speed their sinking. At water impact, the decelerator/parachute assembly is expended and sinks away from the unit. The decelerator/parachute assembly may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the seafloor, where it becomes flattened (Group 2005). Once settled on the bottom the canopy may temporarily billow if bottom currents are present.

Table 58. Size categories for decelerators and parachutes expended during training and testing activities (Navy 2017a).

Size Category	Diameter (feet)	Associated Activity
Small	1.5 to 6	Air-launched sonobuoys, lightweight torpedoes, and drones (drag parachute)
Medium	19	Illumination flares
Large	30 to 50	Drones (main parachute)
Extra-large	82	Drones (main parachute)

Aerial targets (drones) use large (between 30 and 50 ft in diameter) and extra-large (80 ft in diameter) decelerators/parachutes. Large and extra-large decelerators/parachutes are also made of cloth and nylon, with suspension lines of varying lengths (large: 40 to 70 ft in length [with up to 28 lines per decelerator/parachute]; and extra-large: 82 ft in length [with up to 64 lines per decelerator/parachute]). Some aerial targets also use a small drag parachute (6 ft in diameter) to slow their forward momentum prior to deploying the larger primary decelerator/parachute. Unlike the small- and medium-sized decelerators/parachutes, drone decelerators/parachutes do not have weights attached and may remain at the surface or suspended in the water column for some time prior to eventual settlement on the seafloor.

6.5.3 Biodegradable Polymer

Marine vessel stopping payloads are systems designed to deliver the appropriate measure(s) to affect a vessel's propulsion and associated control surfaces to significantly slow and potentially stop the advance of the vessel. Marine vessel stopping proposed activities include the use of biodegradable polymers designed to entangle or occlude the propellers of in-water vessels. A biodegradable polymer is a polymer that degrades to smaller compounds as a result of microorganisms and enzymes present in the environment.

The biodegradable polymers that the Navy uses are constructed from various amounts and configurations of polyvinyl alcohol (PVA), polylactic acid (PLA), sodium polyacrylate, ethylene vinyl alcohol copolymer (EVOH), and protein based biopolymers. Additional supporting materials comprising small portions of biodegradable polymers include sodium alginate, basalt, beeswax, calcium, castor oil, Borax (sodium tetraborate), citric acid, corn starch, and sodium bicarbonate. These materials would be combined into a variety of different systems designed to temporarily interact with the propeller(s) of a target craft rendering it ineffective. Elements of the system would be sewn together using segments of cellulosic (e.g., cotton or Rayon) threads. Some of the polymer constituents would dissolve within two hours of immersion. Based on the constituents of the biodegradable polymer the Navy proposes to use, it is anticipated that the material will break down into small pieces within a few days to weeks. These will break down further and dissolve into the water column within weeks to a few months. Degradation and dispersal times are influenced by water temperature, currents, and other oceanographic features. Overall, the longer the polymer remains in the water, the weaker it becomes, making it more brittle and likely to break. At the end of dispersion, the remaining materials are generally separated fibers with lengths on the order of 54 micrometers.

6.6 Ingestion Stressors

The Navy expends the following types of materials that could become ingestion stressors during training and testing: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and decelerators/parachutes. Other military expended materials such as targets, large-caliber projectiles, intact training and testing bombs, guidance wires, 55-gallon drums, sonobuoy tubes, and marine markers are too large for marine organisms to consume and are eliminated from further discussion regarding ingestion.

Solid metal materials, such as small-caliber projectiles or fragments from high-explosive munitions, sink rapidly to the seafloor. Lighter plastic items may be caught in currents and gyres or entangled in floating *Sargassum* and could remain in the water column for hours to weeks or indefinitely before sinking (e.g., plastic end caps [from chaff cartridges] or plastic pistons [from flare cartridges]).

6.6.1 Non-Explosive Practice Munitions

Only small- or medium-caliber projectiles and flechettes (small metal darts) from some non-explosive rockets would be small enough for marine animals to ingest, depending on the animal. This is discussed in more detail within each section for ESA-listed species. Small- and medium-caliber projectiles include all sizes up to and including those that are 2.25 in in diameter. Flechettes from some non-explosive rockets are approximately 2 in in length. Each non-explosive flechette rocket contains approximately 1,180 individual flechettes that are released. These solid metal materials would quickly move through the water column and settle to the seafloor.

6.6.2 Fragments from High Explosive Munitions

Many different types of high-explosive munitions can result in fragments that are expended at sea during training and testing activities. Types of high-explosive munitions that can result in fragments include torpedoes, neutralizers, grenades, projectiles, missiles, rockets, buoys, sonobuoys, countermeasures, mines, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the net explosive weight and munition type. These solid metal materials would quickly sink through the water column and settle to the seafloor.

6.6.3 Target Related Materials

At-sea targets are usually remotely-operated airborne, surface, or subsurface traveling units, many of which are designed to be recovered for reuse. However, if they are used during activities that use high-explosives then they may result in fragments and ultimate loss of the target. Expendable targets that may result in fragments would include air-launched decoys, surface targets (e.g., marine markers, cardboard boxes, and 10 ft diameter red balloons), and mine shapes. Most target fragments would sink quickly to the seafloor. Floating material, such as Styrofoam, may be lost from target boats and remain at the surface for some time.

6.6.4 Chaff

Chaff consists of reflective, aluminum-coated glass fibers used to obscure ships and aircraft from radar-guided systems. Chaff, which is stored in canisters, is either dispensed from aircraft or fired into the air from the decks of surface ships when an attack is imminent. The glass fibers create a radar cloud that mask the position of the ship or aircraft. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide (Navy 2017a). Chaff is released or dispensed from cartridges that contain millions of fibers. When deployed, a diffuse cloud of fibers is formed that is undetectable to the human eye. Chaff is a very light material, similar to fine human hair. It can remain suspended in air anywhere from 10 minutes to 10 hours and can travel considerable distances from its release point, depending on prevailing atmospheric conditions (Arfsten et al. 2002; Navy 2017a). Doppler radar has tracked chaff plumes containing approximately 900 grams of chaff drifting 200 miles from the point of release, with the plume covering more than 400 miles (Arfsten et al. 2002).

The chaff concentrations that marine animals could be exposed to following the discharge of multiple cartridges (e.g., following a single day of training) is difficult to accurately estimate because it depends on several variable factors. First, specific release points are not recorded and tend to be random, and chaff dispersion in air depends on prevailing atmospheric conditions. After falling from the air, chaff fibers would be expected to float on the sea surface for some period, depending on wave and wind action. The fibers would be dispersed farther by sea currents as they float and slowly sink toward the bottom.

6.6.5 Flares

Flares are pyrotechnic devices used to defend against heat-seeking missiles, where the missile seeks out the heat signature from the flare rather than the aircraft's engines. Similar to chaff, flares are also dispensed from aircraft. The flare device consists of a cylindrical cartridge approximately 1.4 inches in diameter and 5.8 inches in length. Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic compression pad or piston (0.45 to 4.1 grams depending on flare type). The flare pads and pistons float in sea water.

6.7 Potential Effects on Endangered Species Act (ESA) listed Resources

The stressors described above have the potential to affect ESA-listed resources in the action area in a variety of ways. For example, exposure to acoustic stressors (including explosives) may lead to lethal and non-lethal injury, hearing impairment, behavioral disturbance, physiological stress, and masking. Vessels may collide with ESA-listed marine mammals, sea turtles, or fish. Military expended materials also have the potential to result in entanglement of some ESA-listed animals, injury to ESA-listed corals, and impacts to coral habitat in the action area. Additional detail on these potential effects are discussed in later sections of this opinion.

7 Species and Designated Critical Habitat that May be Affected

This section identifies the ESA-listed species and designated critical habitat that potentially occur within the action area that may be affected by the proposed action. It then identifies those species not likely to be adversely affected by the proposed action because the effects of the proposed action are deemed insignificant, discountable, or fully beneficial. Finally, this section summarizes the biology and ecology of those species that may be adversely affected by the proposed action and details information on their life histories in the action area, if known. The ESA-listed species and designated critical habitat potentially occurring within the action area that may be affected by the proposed action are given in Table 59 and Table 60, along with their regulatory status.

Table 59. ESA-listed species and DPSs that may be affected by the proposed action.

Species	ESA Status	Recovery Plan
Marine Mammals		
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	07/1998
Bowhead Whale (*Balaena mysticetus*)	E – 35 FR 18319	-- --
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	75 FR 47538
Gulf of Mexico Bryde's Whale (*Balaenoptera edeni*)	E – 81 FR 88639 (Proposed)	-- --
North Atlantic Right Whale (*Eubalaena glacialis*)	E – 73 FR 12024	70 FR 32293
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	12/2011
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	75 FR 81584
Ringed Seal (*Phoca hispida hispida*) –Arctic subspecies	T – 77 FR 76706	-- --
Marine Reptiles		
Green Sea Turtle (*Chelonia mydas*) – North Atlantic DPS	T – 81 FR 20057	U.S. Atlantic 1991
Hawksbill Sea Turtle (*Eretmochelys imbricata)*	E – 35 FR 8491	63 FR 28359 and 57 FR 38818
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	E – 35 FR 18319	9/2011
Leatherback Sea Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	63 FR 28359 and 10/1991
Loggerhead Sea Turtle (*Caretta caretta*) – Northwest Atlantic Ocean DPS	T – 76 FR 58868	74 FR 2995
Fishes		
Atlantic Salmon (*Salmo salar*) – Gulf of Maine DPS	E – 74 FR 29344 and 65 FR 69459	70 FR 75473 and 81 FR 18639 (Draft) 12/2005 03/2016
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Carolina DPS	E – 77 FR 5913	-- --
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Chesapeake Bay DPS	E – 77 FR 5879	-- --
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Gulf of Maine DPS	E – 77 FR 5879	-- --
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – New York Bight DPS	E – 77 FR 5879	-- --
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – South Atlantic DPS	E – 77 FR 5913	-- --
Giant Manta Ray (*Manta birostris*)	T -- 83 FR 2916	-- --
Gulf Sturgeon (*Acipenser oxyrinchus desotoi*)	T – 56 FR 49653	09/1995
Nassau Grouper (*Epinephelus striatus*)	T – 81 FR 42268	-- --
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	T – 83 FR 4153	-- --
Scalloped Hammerhead Shark (*Sphyrna lewini*) – Central and Southwest Atlantic DPS	T – 79 FR 38213	-- --
Shortnose Sturgeon (*Acipenser brevirostrum*)	E – 32 FR 4001	63 FR 69613
Smalltooth Sawfish (*Pristis pectinata*) – U.S. portion of range DPS	E – 68 FR 15674	74 FR 3566
Invertebrates		
Boulder Star Coral (*Orbicella franksi*)	T – 79 FR 53851	

Species	ESA Status	Recovery Plan
Elkhorn Coral (*Acropora palmata*)	T – 79 FR 53851	80 FR 12146
Lobed Star Coral (*Orbicella annularis*)	T – 79 FR 53851	
Mountainous Star Coral (*Orbicella faveolata*)	T – 79 FR 53851	
Rough Cactus Coral *(Mycetophyllia ferox)*	T – 79 FR 53851	
Pillar Coral (*Dendrogyra cylindrus*)	T – 79 FR 53851	
Staghorn Coral (*Acropora cervicornis*)	T – 79 FR 53851	80 FR 12146

Table 60. ESA-designated critical habitat that occurs within the action area and may be affected by the proposed action.

Designated Critical Habitat	Federal Register Notice	Units
Marine Reptiles		
Green Turtle (*Chelonia mydas*) – North Atlantic DPS Critical Habitat	63 FR 46693	-- --
Hawksbill Turtle (*Eretmochelys imbricata)* Critical Habitat	63 FR 46693	-- --
Leatherback Turtle (*Dermochelys coriacea*) Critical Habitat	44 FR 17710 and 77 FR 4170	-- --
Loggerhead Turtle (*Caretta caretta*) – Northwest Atlantic Ocean DPS Critical Habitat	79 FR 39856	LOGG-N-01 to LOGG-N-36, LOGG-S-1 to LOGG-S-1
Fishes		
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Carolina DPS Critical Habitat	82 FR 39160	-- --
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Chesapeake DPS Critical Habitat	82 FR 39160	-- --
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Gulf of Maine DPS Critical Habitat	82 FR 39160	-- --
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – New York Bight DPS Critical Habitat	82 FR 39160	-- --
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – South Atlantic DPS Critical Habitat	82 FR 39160	-- --
Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) Critical Habitat	68 FR 13370	-- --
Invertebrates		
Elkhorn Coral (*Acropora palmata*) Critical Habitat	73 FR 72210	-- --
Staghorn Coral (*Acropora cervicornis*) Critical Habitat	73 FR 72210	-- --

7.1 Species and Designated Critical Habitat Not Likely to be Adversely Affected

NMFS uses two criteria to identify the ESA-listed species or designated critical habitat that are not likely to be adversely affected by the proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If we conclude that an ESA-listed species or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. An ESA-listed species or designated critical habitat that is exposed to a potential stressor but is likely to be unaffected by the exposure is also not likely to be adversely affected by the proposed action.

An action warrants a "may affect, not likely to be adversely affected" finding when its effects are wholly *beneficial, insignificant* or *discountable*. *Beneficial* effects have an immediate positive effect without any adverse effects to the species or habitat. Beneficial effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs, and consultation is required because the species may be affected.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect. That means the ESA-listed species may be expected to be affected, but not harmed or harassed.

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did impact a listed species), but it is very unlikely to occur.

We applied these criteria to the ESA-listed resources in Table 59 and Table 60 and we summarize our results below.

7.1.1 Bowhead Whale

The bowhead whale is a circumpolar baleen whale found throughout high latitudes in the Northern Hemisphere and was originally listed as endangered on December 2, 1970 (35 FR 18319). Bowhead whales are the northernmost of all whales and are found in arctic and subarctic regions of the Atlantic and Pacific Oceans (55° N to 85° N). They are also found in the Bering, Beaufort, Chukchi, and Okhotsk Seas, as well as in the northern parts of Hudson Bay (Wiig et al. 2007). Their range can expand and contract depending on access through ice-filled Arctic straits (Rugh et al. 2003). Habitat selection varies seasonally. Bowhead whales are found in continental slope and shelf waters during spring and summer while feeding on abundant zooplankton (Citta et al. 2015) (Wiig et al. 2007).

Three geographically distinct bowhead whale stocks are recognized in the Atlantic: the Spitsbergen, Baffin Bay-Davis Strait, and Hudson Bay-Fox Basin stocks (Muto and Angliss 2016; Rugh et al. 2003; Wiig et al. 2007). Satellite tracking studies of whales tagged from the Baffin Bay-Davis Strait and Hudson Bay-Fox Basin stocks suggested and confirmed these two stocks should be considered as one stock (Eastern Canada-West Greenland stock) based on overlapping wintering areas (Frasier et al. 2015; Heide-Jorgensen et al. 2006). Migration is associated with ice edge movements. All Atlantic stocks reside in higher Arctic latitudes during summer and move south in fall as the ice edge grows, spending their winters within the marginal ice zone in lower-latitude areas (Jefferson et al. 2015). The Eastern Canada-West Greenland stock spends winters in northern Hudson Bay, Hudson Strait, and from Labrador across to west Greenland and move north to spend summers in the Canadian High Arctic and around Baffin Island (Heide-Jorgensen and Laidre 2003). Summer aggregation areas are in northern Hudson Bay and around Baffin Island.

The winter range of the Eastern Canada-West Greenland stock includes the shelf areas of west Greenland, northeastern Hudson Bay and Hudson Strait, the mouths of Cumberland Sound and Frobisher Bay on southeast Baffin Island, and northern Labrador. Bowhead whales would be expected to occur in winter within the Newfoundland-Labrador and Western Greenland Shelf Large Marine Ecosystems from November through April (Heide-Jorgensen et al. 2006). Two bowhead whales were stranded on Newfoundland in 1998 and 2005, from 45° N to 47° N and 52° W to 56° W, which at the time represented the southernmost records of this species in the western North Atlantic (Ledwell et al. 2007). In March 2012, a bowhead whale was observed in Cape Cod Bay and the same whale (identified from photographs) was again observed in Cape Cod Bay in April 2014 (Navy 2017a). These sightings now represent the southernmost record of this species in the western North Atlantic.

Based on the information provided above, only the northern portions of the action area overlap with habitats where bowhead whales typically occur. According to the Navy's BA, Navy vessels may transit into these areas infrequently, but no sonar or other transducers, explosives, electromagnetic devices, lasers, in-water devices, military expended materials, or seafloor devices would be used in these areas. Because Navy vessels travel into habitat typically occupied by bowhead whales so infrequently, it is extremely unlikely that a Navy vessel will encounter a bowhead whale in the northern portions of the action area (and pose a risk of vessel strike or exposing a whale to vessel noise). Further, because only one bowhead whale has ever been observed in more southern portions of the action area, NMFS considers it extremely unlikely that a bowhead whale will co-occur with Navy training and testing activities in these areas (and being exposed to stressors from these activities). Therefore, the potential effects of the proposed action on bowhead whales are discountable. For these reasons, Navy training and testing activities are not likely to adversely affect bowhead whales and this species will not be considered further in this opinion.

7.1.2 Ringed Seal – Arctic Subspecies

On December 28, 2012, NMFS published a final rule listing the Arctic, Okhotsk, and Baltic subspecies as threatened, and the Ladoga and Saimaa subspecies as endangered. Arctic ringed seals occur in U.S. waters off Alaska's coast. On March 11, 2016, the U.S. District Court for the District of Alaska issued a decision vacating NMFS' December 28, 2012, listing of the Arctic ringed seal as threatened. Therefore, at this time, Arctic ringed seals are not listed as a threatened species under the ESA. A notice of appeal of the District Court decision was filed on May 3, 2016. On February 12, 2018, the U.S. Court of Appeals for the Ninth Circuit reversed the District Court's decision and upheld NOAA Fisheries' decision to List the Arctic subspecies of ringed seals as threatened. Consequently, the listing of Arctic subspecies of ringed seals as threatened will be reinstated once the Ninth Circuit issues its mandate to the District Court and the District Court then enters final judgment in this case.

Ringed seals have a circumpolar distribution throughout the Arctic basin, Hudson Complex, and the Bering, Okhotsk, and Baltic Seas. The distribution of ringed seals is strongly correlated with pack and land-fast ice (Born et al. 2002; Jefferson et al. 2015) in areas over virtually any water depth (Reeves 1998). Although they are generally not considered migratory, ringed seals are known to make long-distance movements (Teilmann et al. 1999). In the western Atlantic, ringed seals occur as far south as northern Newfoundland, northward to the pole, and throughout the Canadian Arctic. They also occur throughout the Greenland Large Marine Ecosystem and can be found as far south as Labrador off the Canadian east coast in the Newfoundland-Labrador Shelf Large Marine Ecosystem (Hammill 2009).

According to the Navy's BA, Navy vessels may transit into Arctic subspecies ringed seal habitat infrequently, but no sonar or other transducers, explosives, electromagnetic devices, lasers, in-water devices, military expended materials, or seafloor devices would be used in these areas. Based on the information provided above, only the northern portions of the action area overlap with habitats where the Arctic subspecies of ringed seals typically occur. Because Navy vessels travel into these areas so infrequently, NMFS considers it extremely unlikely that a Navy vessel will encounter this species in the northern portions of the action area (and posing a risk of vessel strike or exposing a seal to vessel noise). Therefore, the potential effects of the proposed action on Arctic subspecies ringed seals are discountable. For these reasons, Navy training and testing activities are not likely to adversely affect the Arctic subspecies of ringed seals and this species will not be considered further in this opinion.

7.1.3 Nassau Grouper

The Nassau grouper was listed as threatened on June 29, 2016. The Nassau grouper is a large, long-lived fish, and primarily inhabits shallow water throughout the Caribbean, south Florida, Bermuda, and the Bahamas. Nassau grouper may occur in the southern portion of the Navy's Jacksonville Range Complex and in the Key West and Gulf of Mexico Range Complexes. They occur in nearshore areas, around coral reefs and within rocky substrates, and may also occur in waters as deep as 100 m.

Based on our effects analysis of the proposed actions on Nassau grouper, we estimate that for many of the stressors (e.g. weapons noise, sonar and other transducers, air guns, pile driving, in-water electromagnetic devices, military expended materials, etc.), Nassau grouper will not be present, or would only have a very low probability of being adversely affected if they were present, due to the small portions of the action area that they occupy. Although they may be exposed to some of the stressors discussed in this opinion, the magnitude and duration of exposures are expected to be brief, episodic and are not expected to result in any harm or harassment to Nassau grouper. However, the stressor that would be the most likely to adversely affect Nassau grouper would be from explosives, discussed below.

Because they have the potential to be present within the action area during Navy training activities that use explosives, Nassau grouper could be exposed to sound and energy from explosives throughout the year. The southern portions of the Jacksonville Range Complex are not the portion of the range complex where explosives are used (i.e., outside of the Jacksonville OPAREA), therefore Nassau grouper are not expected to be exposed to explosives within this area. Within the KWRC, the probability that Nassau grouper would be exposed to explosives would also be very low. Nassau grouper may be present on or near coral reefs within these areas, but these areas are protected from exposure due to mitigation measures that Navy will implement to prevent explosives from being discharged on mapped coral reefs (Section 3.4.2.2.1). Similarly, Nassau grouper could occur in the Gulf of Mexico Range Complex but would be expected to be located in areas around Flower Garden Banks which is a very small portion of the overall range complex. Moreover, the Navy does not propose to conduct any explosives use in the Flower Gardens Banks National Marine Sanctuary. Testing activities that are conducted in the KWRC and the Naval Surface Warfare Center, Panama City Division Testing Range may use the explosives categorized into small bin sizes like E5; however, some larger charge sizes (e.g., E14) are also used in these range complexes, but most of the energy from E14 is expected to be lost in the air or to the bottom substrate due to detonation in very shallow water (i.e., the air or bottom substrate is away from where Nassau grouper are likely to be present). No ship shock trials are expected to occur in offshore areas where Nassau grouper could occur. Given that Nassau grouper are not likely to be exposed to injurious sound levels produced during the use of explosives, no injury, mortality or hearing loss is expected. If, however, a Nassau grouper encountered expended materials that may drop through the water column, or along the substrate at later point in time only brief and temporary behavioral responses would be expected. Similarly, if a Nassau grouper were able to detect an acoustic sound source (e.g. hear it) from far away, we do not anticipate any injury to occur, but rather only mild behavioral responses indicating the fish detects an acoustic stimulus. We do not anticipate the potential for fitness consequences of any Nassau grouper to occur from these temporary changes in behavior. Similarly, we do not anticipate any long-term adverse effects on either individual fish or the population resulting from temporary changes in behavior. Therefore, we consider the effects of

Navy training and testing activities to be insignificant and discountable for Nassau grouper, and this species will not be discussed further.

7.1.4 Shortnose Sturgeon

The shortnose sturgeon was listed as endangered on March 11, 1967. Shortnose sturgeon remained on the endangered species list with enactment of the ESA in 1973. Shortnose sturgeon occur in estuaries and rivers along the east coast of North America (Vladykov and Greeley 1963). Their northerly distribution extends to the Saint John River, New Brunswick, Canada, and their southerly distribution historically extended to the Indian River, Florida (Evermann and Bean 1898; Scott and Scott 1988). Shortnose sturgeon overwinter in the lower portions of rivers and migrate upriver to spawn in the spring. The general pattern of coastal migration of shortnose sturgeon indicates movement between groups of rivers proximal to each other across the geographic range.

Although they spend their time primarily in river systems, shortnose sturgeon occasionally enter estuarine and coastal marine waters and could potentially encounter some of the stressors described in this opinion (such as sonar, other active acoustic sources, pile driving, explosives, air guns, weapons firing noise, aircraft noise, vessel noise, electromagnetic devices, vessels and in-water devices, and seafloor devices). Because shortnose sturgeon primarily occur in riverine habitats they are expected to be located outside the limits of most of the action area. For this reason, and their generally low population numbers along most of their range, they are extremely unlikely to encounter most of the stressors considered in the biological opinion.

Recently, Dr. Matt Balazik documented two extralimital occurrences of shortnose sturgeon in the James River, Virginia in March 2016 and February 2018 (Navy 2018). These two occurrences of shortnose sturgeon were discovered when they were captured by researchers while fishing for Atlantic sturgeon. The shortnose sturgeon captured in February 2018 was implanted with a telemetry transmitter and subsequent tracking of this individual in the Navy's lower Chesapeake Bay telemetry receiver array showed that it made a single day excursion out of the James River in mid-March 2018. This animal was detected moving out into the bay as far as the Chesapeake Bay Bridge-Tunnel and returning to the mouth of the James River, and finally detected moving north up the Chesapeake Bay in late April. Based upon this single day movement, this placed the fish, within the range of where pile driving activities may occur at Joint Expeditionary Base Little Creek-Fort Story, Virginia. However, given that the only documented shortnose sturgeon in this area placed a single animal within the vicinity of where pile driving activities may occur, it is extremely unlikely that a shortnose sturgeon would encounter, or be impacted by, pile driving activities.

The Navy also concluded there was an ingestion risk for military expended materials that settle along the seafloor, and shortnose sturgeon may be adversely affected should they ingest this material. This would likely occur in the Northeast, Navy Cherry Point, and Jacksonville Range Complexes particularly in Narragansett, Rhode Island and the Cooper River, South Carolina where activities overlap with known shortnose sturgeon occurrence. In these inshore waters, shortnose sturgeon have a greater chance of encountering military expended materials (munitions). The Navy notes that munitions are much more densely aggregated here due to continued activities in small confined areas. Thus, although unlikely, the potential increase in shortnose sturgeon numbers in this area and larger concentration of expended munitions, sturgeon ingestion risk is higher. The Navy only uses small-caliber brass casings in these areas that drop into the water while firing blank rounds. The diet of shortnose sturgeon is comprised of some prey items that have hard body parts (e.g. shells and carapaces from mollusks and shrimp) so there is a potential for them to mistakenly ingest some of the expended munitions. However, because they normally are able to pass small, hard bodied prey, a small caliber casing is unlikely to cause a blockage or other digestive issues as these items are relatively small and smooth and would likely pass through a sturgeon's digestive tract without causing harm. Therefore, the potential effects of rare cases where shortnose sturgeon ingest munitions are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

For the reasons described above, Navy training and testing activities are not likely to adversely affect shortnose sturgeon, and this species will not be discussed further in this opinion.

7.1.5 Loggerhead Sea Turtle – Northwest Atlantic Ocean Distinct Population Segment (DPS) Designated Critical Habitat

Designated critical habitat for the Northwest Atlantic Ocean distinct population segment (DPS) of loggerhead sea turtles occurs within the action area, along the U.S. Atlantic and Gulf of Mexico coasts, from North Carolina to Mississippi (Figure 17). The designated critical habitat includes five different units, each supporting an essential biological function for loggerhead sea turtles. These units include nearshore reproductive habitat, winter habitat, Sargassum habitat, breeding habitat, and constricted migratory habitat. In total, the designated critical habitat is composed of 38 occupied marine areas and 685 miles of nesting beaches. The physical and biological features of each unit of designated critical habitat are given in Table 61 below.

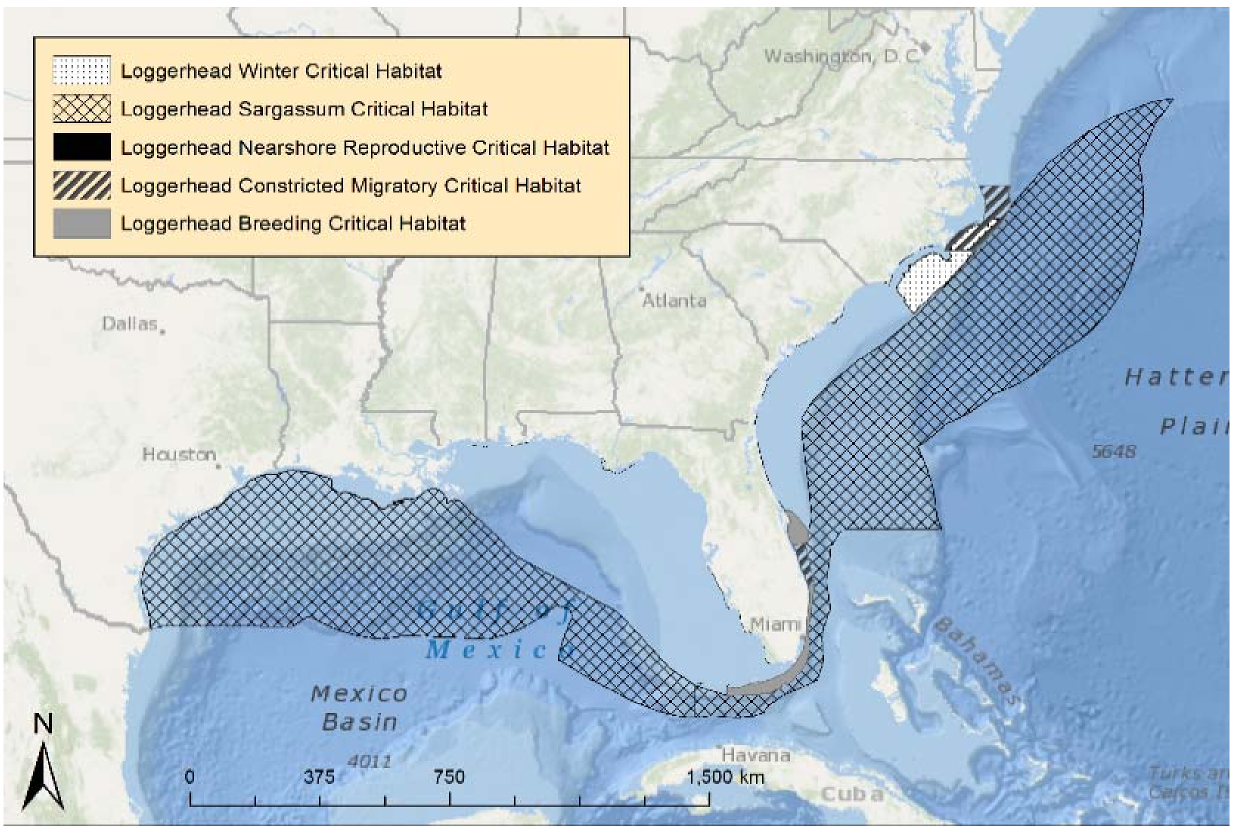


Figure 17. Designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead sea turtles.

Table 61. Physical or biological features for loggerhead critical habitat units.

Loggerhead critical habitat unit	Essential Biological Features
Nearshore Reproductive Habitat	1. Nearshore waters directly off the highest density nesting beaches and their adjacent beaches as identified in 50 C.F.R. §17.95(c) to 1.6 kilometers [km] offshore. 2. Waters sufficiently free of obstructions or artificial lighting to allow transit through the surf zone and outward toward open water. 3. Waters with minimal manmade structures that could promote predators (i.e., nearshore predator concentration caused by submerged and emergent offshore structures), disrupt wave patterns necessary for orientation, and/or create excessive longshore currents.
Winter Habitat	1. Water temperatures above 10° C from November through April. 2. Continental shelf waters in proximity to the western boundary of the Gulf Stream. 3. Water depths between 20 and 100 m.
Breeding Habitat	1. High densities of reproductive male and female loggerheads. 2. Proximity to primary Florida migratory corridor. 3. Proximity to Florida nesting grounds.
Migratory Habitat	1. Constricted continental shelf area relative to nearby continental shelf waters that concentrate migratory pathways. 2. Passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas.
Sargassum Habitat	1. Convergence zones, surface-water downwelling areas, the margins of major boundary currents (Gulf Stream), and other locations where there are concentrated components of the *Sargassum* community in water temperatures suitable for the optimal growth of *Sargassum* and inhabitance of loggerheads. 2. *Sargassum* in concentrations that support adequate prey abundance and cover. 3. Available prey and other material associated with *Sargassum* habitat including, but not limited to, plants and cyanobacteria and animals native to the *Sargassum* community such as hydroids and copepods. 4. Sufficient water depth and proximity to available currents to ensure offshore transport (out of the surf zone), and foraging and cover requirements by *Sargassum* for post-hatchling loggerheads, i.e., >10 m depth.

Within the action area, loggerhead critical habitat may be affected by sonar and other transducers, vessel noise, weapon noise, and explosives. These stressors are not anticipated to effect nearshore reproductive, winter, and breeding critical habitat since the proposed activities are will not occur in these areas. However, constricted migratory and *Sargassum* critical habitat for loggerhead sea turtles may be affected by these stressors.

7.1.5.1 Constricted Migratory Habitat

All of the stressors described above have the potential to affect passage conditions that allow for migration of loggerhead turtles to and from nesting, breeding, and/or foraging areas. Specifically, the common stressor of noise produced by sonar and other transducers, vessels, weapons, and explosives may alter designated constricted migratory critical habitat such that sea turtles may avoid this habitat or alter their migration. However, based on the frequency of these activities, their temporary nature, their relatively small footprint at any given time compared to the amount of available migratory habitat, and given that Navy activities would be spread across a large geographic area, the effects of noise produced by these activities is not likely to have significant effects on passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas. Our determination is based this rationale, and also based on the fact that sea turtles are not known to rely heavily on sound for life functions (Nelms et al. 2016; Popper et al. 2014), and instead appear to rely on other senses such as vision (Narazaki et al. 2013), chemical cues (Endres et al. 2016), and magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015). As such, while noise from the proposed action may have minor effects on passage conditions within designated constricted migratory critical habitat, it is not expected to have meaningful effects on the conservation value of designated constricted migratory critical habitat for loggerhead sea turtles (Northwest Atlantic Ocean DPS). Thus, the effects of noise on designated constricted migratory critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

In summary, the proposed action may affect, but is not is likely to adversely affect, designated constricted migratory critical habitat for loggerhead sea turtles (Northwest Atlantic Ocean DPS). As a result, the potential effects of the proposed action on designated constricted migratory critical habitat for loggerhead sea turtles (Northwest Atlantic Ocean DPS) will not be considered further in this opinion.

7.1.5.2 Sargassum Habitat

The proposed action may also affect constricted *Sargassum* critical habitat due to the effects of sonar and transducers, as well as explosives. These stressors may affect the physical and biological features of designated *Sargassum* critical habitat, specifically prey associated with *Sargassum* habitat.

We are not aware of any research examining the effects of active sonar on prey species in *Sargassum* habitat, although the sound produced by sonar is not anticipated to cause mortality or injury to loggerhead prey species due to the lack of fast rise times, high peak pressures, and the lack of high acoustic impulse of sonar. However, explosives may elicit behavioral responses from prey. Invertebrate species generally have their greatest sensitivity to sound below one to three kHz (Kunc et al. 2016) and would therefore not be capable of detecting mid- or high-frequency sounds, including the majority of sonars, or distant sounds in the action area, though some invertebrate prey in *Sargassum* could likely detect low-frequency sonars. Research has documented behavioral responses of other invertebrates (i.e., squid, crabs) to anthropogenic noise (McCauley et al. 2000c) (Lagardere 1982; Wilson et al. 2007) and we assume that at least some species of loggerhead sea turtle prey found in *Sargassum* may exhibit a behavioral response if exposed to low-frequency sonars similar to these species. However, we anticipate no harm will occur to these exposed animals, and they will resume normal behaviors immediately after the sound exposure is over and remain available to loggerhead sea turtles. Additionally, we expect that the Navy's proposed mitigation to avoid the use of active sonar near floating vegetation, including *Sargassum*, would reduce the source levels prey associated with *Sargassum* would be exposed to, thereby minimizing any potential behavioral response they may exhibit. As such, while sonar and other transducers may affect prey in designated *Sargassum* critical habitat, they are not expected to have meaningful effects on the conservation value of designated *Sargassum* critical habitat for loggerhead sea turtles (Northwest Atlantic Ocean DPS). Thus, the effects of sonar and other transducers on designated *Sargassum* critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

The use of explosives has the potential to affect *Sargassum* concentrations that support adequate prey abundance and cover, as well as available prey and other material associated with *Sargassum* habitat including, but not limited to, plants and cyanobacteria and animals native to the *Sargassum* community such as hydroids and copepods. Detonation of explosive devices near or within *Sargassum* would destroy *Sargassum* as well as nearby prey.

Explosions produce pressure waves with the potential to cause injury or physical disturbance to invertebrate prey such as copepods due to rapid pressure changes, as well as loud, impulsive, broadband sounds. Most marine invertebrates, including copepods and hydroids, lack air cavities and are therefore comparatively less vulnerable to the damaging effects of pressure waves. Additionally, when explosive munitions detonate, fragments of the weapon are thrown at high velocity from the detonation point, which can injure or kill invertebrates if they are struck. However, the friction of the water quickly slows these fragments to the point where the explosion would have to be very close to prey to pose a threat.

Noise from explosives is similar to that produced by seismic air guns in that it is characterized by rapid pressure changes, as well as loud, impulsive, broadband sounds (Hildebrand 2009b). Recent evidence from McCauley et al. (2017) indicates that impulsive sounds such as seismic air guns may lead to a significant reduction in zooplankton (either death, avoidance, or both), including copepods, out to a distance of at least 1.2 kilometers (km) from the air gun source. In order for these effects to have a significant impact at an ecological scale, the spatial or temporal scale of the seismic activity would likely need to be large in comparison to the ecosystem in question due to the naturally fast turnover rate of zooplankton (McCauley et al. 2017).

The majority of prey available to loggerhead sea turtles in designated *Sargassum* critical habitat are expected to be near the surface (Witherington et al. 2012), where many of the proposed explosives would occur. As such, the use of explosives in designated *Sargassum* critical habitat is expected to affect the physical and biological features of *Sargassum* habitat due to both the physical destruction of nearby *Sargassum* and prey caused by fragments, as well the effects of noise produced by explosives, which may impact prey well beyond the immediate vicinity of the explosion. However, such impacts are expected to be relatively minor and temporary given the high turnover rate of zooplankton and the currents in the North Atlantic gyre and the Gulf Stream, which would circulate *Sargassum* into designated loggerhead critical habitat within the action area (see Richardson et al. 2017 for simulations based on the results of McCauley et al. 2017 that suggest ocean circulation greatly reduced the impact of seismic surveys on zooplankton at the population level). Moreover, as discussed in Section 3.4.2, the Navy will use Lookouts to search for floating vegetation, including *Sargassum* mats, and not use explosives if floating vegetation is observed. Given these reasons, the effects of explosives on designated *Sargassum* critical habitat is expected to be minor and localized.

As such, while the use of explosives may temporarily alter *Sargassum* concentrations and prey abundance in designated loggerhead *Sargassum* critical habitat, it is not expected to have meaningful effects on the conservation value of designated *Sargassum* critical habitat for loggerhead sea turtles (Northwest Atlantic Ocean DPS). Thus, the effects of explosives on designated *Sargassum* critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

In conclusion, the proposed action may affect, but is not is likely to adversely affect, designated *Sargassum* critical habitat for loggerhead sea turtles (Northwest Atlantic Ocean DPS). As a result, the potential effects of the proposed action on designated *Sargassum* critical habitat for loggerhead sea turtles (Northwest Atlantic Ocean DPS) will not be considered further in this opinion.

7.1.6 Atlantic Sturgeon Designated Critical Habitat

On September 18, 2017, NMFS designated critical habitat for Atlantic sturgeon (82 FR 39160). Designated critical habitat for the threatened Gulf of Maine DPS, the endangered New York Bight DPS, the endangered Chesapeake Bay DPS, the endangered Carolina DPS, and the endangered South Atlantic DPS of Atlantic sturgeon occurs within the action area, in coastal rivers from Maine to Florida (Figure 18).

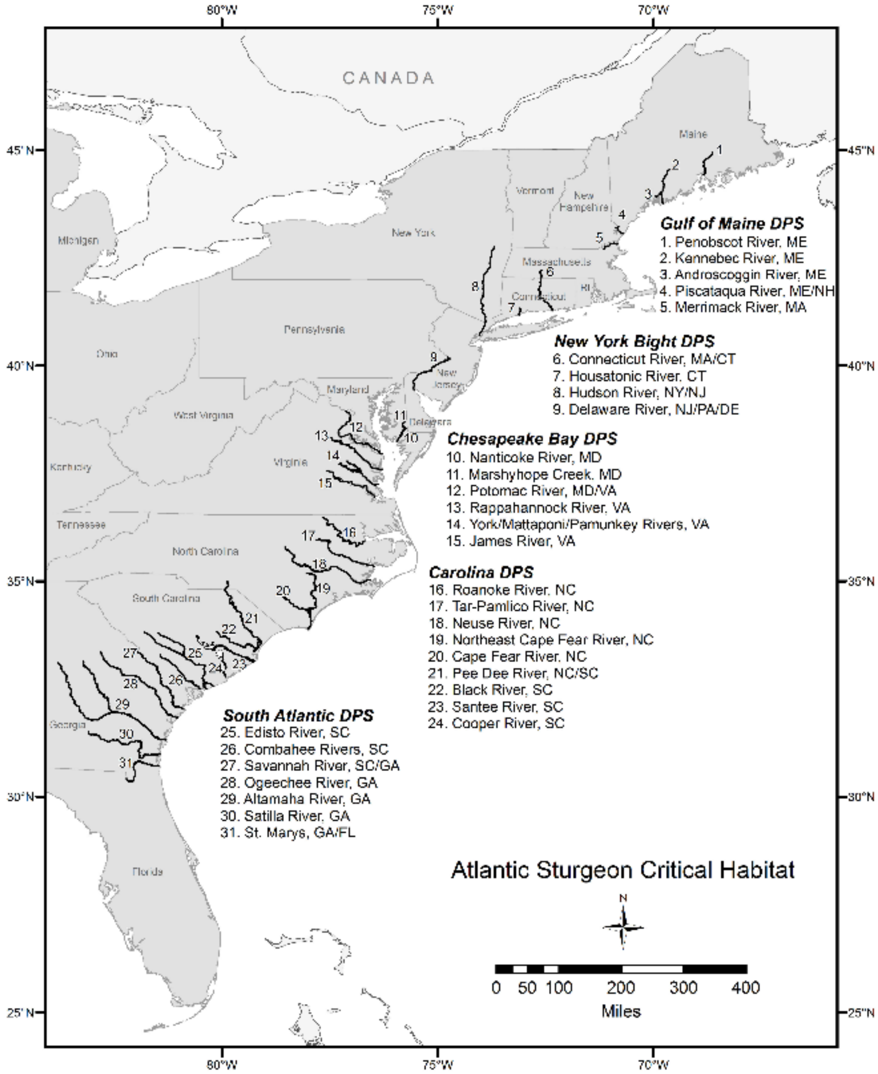


Figure 18. Map showing the 31 coastal rivers designated as critical habitat for Atlantic sturgeon.

The physical and biological features essential for the conservation of Atlantic sturgeon belonging to the Gulf of Maine, New York Bight, and Chesapeake Bay DPSs are:

1. Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0-0.5 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: (i) Unimpeded movement of adults to and from

spawning sites; (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (iii) Staging, resting, or holding of sub adults or spawning condition adults. Water depths in main river channels must also be deep enough (e.g., at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river;

4. 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 inter-annual adult, sub adult, larval, and juvenile survival; and (iii) Larval, juvenile, and sub adult growth, development, and recruitment (e.g., 13 to 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 and biological features essential for the conservation of Atlantic sturgeon belonging to the Carolina, and South Atlantic DPSs are:

1. Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0-0.5 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: (i) Unimpeded movement of adults to and from spawning sites; (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (iii) Staging, resting, or holding of sub adults or spawning condition adults. Water depths in main river channels must also be deep enough (at least 1.2 m) 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" (i) Spawning; (ii) Annual and inter-annual adult, sub adult, larval, and juvenile survival; and (iii) Larval, juvenile, and sub adult 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.

Suitable fish passage is one of the physical and biological features identified for designated Atlantic sturgeon critical habitat (all DPSs). All of the proposed Navy activities that overlap with designated Atlantic sturgeon critical habitat that involve the physical presence of the Navy and/or the production of noise have the potential to create physical barriers that may affect the passage of Atlantic sturgeon. Activities that may create a barrier include the use of vessels, sonar and other transducers, in-water devices, expended military material, and seafloor devices.

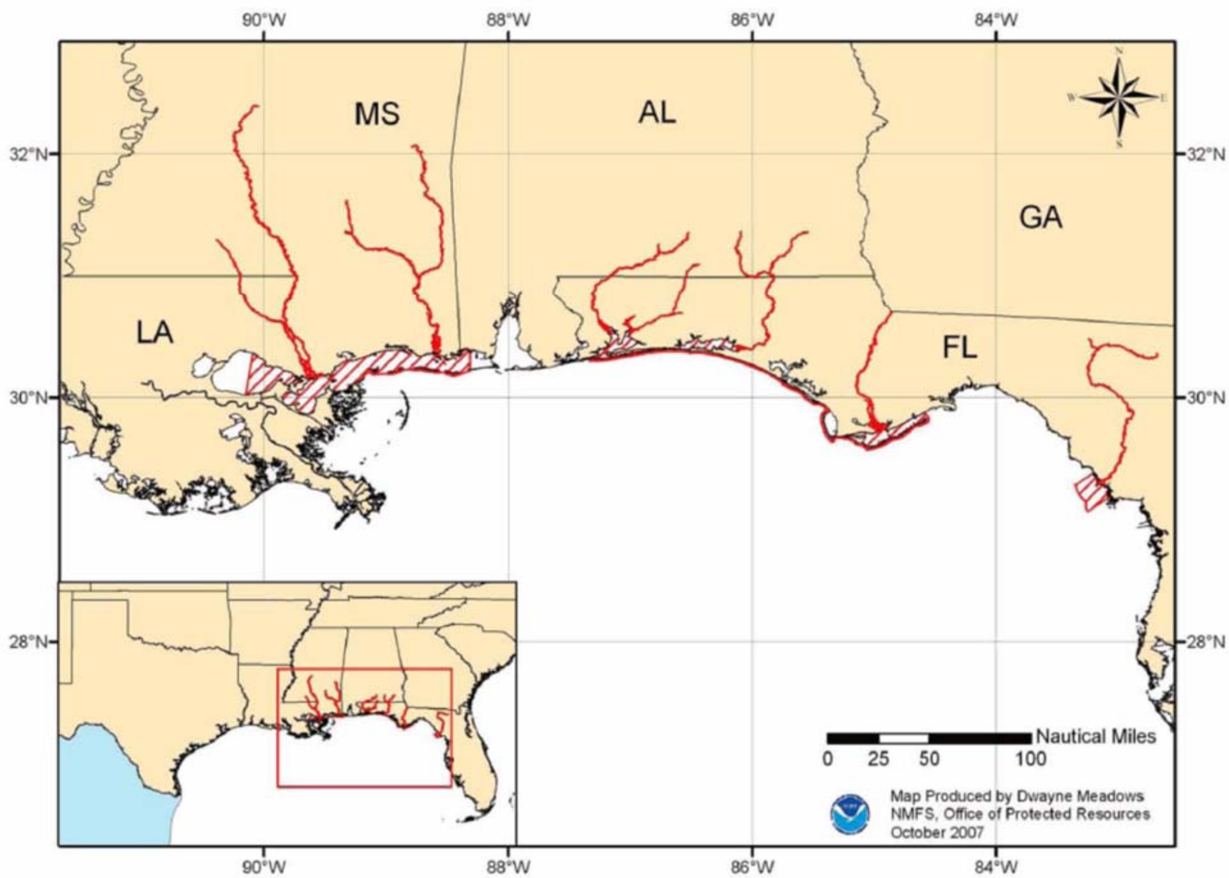
The physical presence of objects such as vessels and in-water devices may act as a physical obstacle that could alter sturgeon movement, while activities that produce noise that would be audible to sturgeon (e.g., mid and low frequency sonar, vessel noise, see Section 7.2.13.3) may act as a sonic obstacle that could alter sturgeon movement. However, we anticipate the effects of these stressors on Atlantic sturgeon movement and passage would be temporary and minor for several reasons. First, the proposed activities will not occur in any migration corridor for a duration that would alter sturgeon movement, or impede sturgeon from accessing spawning or rearing habitat. Second, the effects on passage are expected to be localized and only occur in a portion of the water column (e.g., vessels at the surface, seafloor devices at the seafloor), meaning there would not be a complete blockage of passage, likely only temporary, minor changes in sturgeon movement to avoid the immediate vicinity of Navy's activities. The placement or expenditure of objects in areas of designated Atlantic sturgeon critical habitat characterized by soft substrate would cover the substrate for a relatively short period of time in the case of seafloor devices (which are retrieved), or in the case of expended military material, until the object degrades or is covered by additional sediment. However, given that only a small portion of soft substrate would be covered and unavailable, and that after the removal of seafloor devices or degradation or covering of expended military material this habitat is expected to become available again, we do not anticipate that the use of seafloor devices and expended military material would have meaningful effects on the conservation value of designated Atlantic sturgeon critical habitat. Thus, the effects of seafloor devices and expended military material on soft substrate in designated Atlantic sturgeon critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

While the stressor of noise may be more pervasive and less localized, noise is not expected to create a complete barrier, with only high level sounds close to sources within the hearing range of sturgeon being those that would affect passage. Popper et al. (2014) concluded that behavioral reactions of fish in response to exposure to mid and low frequency sonar was unlikely, regardless of the distance from the sound source which means that depending on the circumstances, noise from Navy activities may not affect passage at all. Thus, while we expect that the proposed action would have minor effects on fish passage for Atlantic sturgeon critical habitat's ability to function as an area free from barriers, we do not anticipate that this would have meaningful effects on the conservation value of designated Atlantic sturgeon critical habitat over the long-term. Thus, the effects of vessels, sonar and other transducers, in-water devices, expended military material, and seafloor devices on passage in designated Atlantic sturgeon critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

In conclusion, the proposed action may affect, but is not is likely to adversely affect, designated Atlantic sturgeon critical habitat (all DPSs). As a result, the potential effects of the proposed action on designated Atlantic sturgeon critical habitat will not be considered further in this opinion.

7.1.7 Gulf Sturgeon Designated Critical Habitat

Designated critical habitat for Gulf sturgeon occurs within the action area and consists of 14 geographic units encompassing 2,783 river km as well as 6,042 km^2 of estuarine and marine habitat (Figure 40).



Note: Critical habitat is delineated in red.

Figure 19. Map of Gulf Sturgeon designated critical habitat in the Gulf of Mexico (NOAA 2007).

The physical and biological features (formerly primary constituent elements) essential for the conservation of Gulf Sturgeon include (69 FR 13370):

1. Abundant food items, such as detritus, aquatic insects, worms, and/or mollusks, within riverine habitats for larval and juvenile life stages; and abundant prey items, such as amphipods, lancelets, polychaetes, gastropods, ghost shrimp, isopods, mollusks and/or

crustaceans, within estuarine and marine habitats and substrates for sub adult 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, sub adult, 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 fresh water discharge over time) necessary for 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 for maintaining spawning sites in suitable condition for egg attachment, egg sheltering, resting, and larval staging;
5. 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;
6. Sediment quality, including texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; and
7. Safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (e.g., an unobstructed river or a dammed river that still allows for passage).

Proposed Navy training and testing 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, specifically in the Panama City OPAREA. The Panama City OPAREA lies off the coast of the Florida panhandle and totals approximately 3,000 NM^2. The vast majority of this OPAREA does not include designated critical habitat and most activities using explosives in this OPAREA are unlikely to occur in nearshore waters where Gulf sturgeon critical habitat has been designated.

According to the Navy's BA, line charge testing is the only activity involving explosives that is likely to be conducted in Gulf sturgeon designated critical habitat. These activities are proposed to occur four times annually. Other activities using explosives in the Panama City OPAREA are expected to occur greater than 3 NM from shore, outside of designated critical habitat. During line charge testing, surface vessels deploy line charges to test the capability to safely clear surf zone areas for sea-based expeditionary forces. Line charges consist of a 350 ft detonation cord with a series of explosives lined end-to-end in 5- pound increments. When the charges are detonated, Gulf sturgeon prey in the vicinity are likely to be injured or killed. While the total net explosive weight of a line charge is relatively large, the individual charges are each only 5 pounds. For this reason, the range to injury or mortality for Gulf sturgeon prey around the 350-ft detonation cord will be relatively small and effects to Gulf sturgeon prey will be localized.

Effects on prey abundance are also expected to be temporary as following the explosion, unaffected animals in close proximity will likely move into the area that was disturbed by the explosive to utilize the unoccupied habitat. Because reductions in prey abundance will be temporary and localized, this reduces the likelihood that any reduction in prey abundance would occur when Gulf sturgeon are utilizing the habitat. Also important to note is that a limited number of line charges are proposed for use in this area annually (i.e., four total annually). Finally, per Table 32, the Navy will implement mitigation such that line charges will not be used in Gulf sturgeon designated critical habitat from October through March, during the Gulf sturgeon migration season and when the species is most likely to be present (and foraging) in these areas.

In summary, we anticipate reductions in abundance of Gulf sturgeon prey in designated critical habitat from the use of explosives, but these reductions in abundance will be highly localized and temporary. Additionally, the Navy will implement mitigation to avoid conducting line charge testing in Gulf sturgeon critical habitat during times of the year when the animals are most likely to be foraging in these locations. For these reasons, the effects of Navy explosive use on prey resources in Gulf sturgeon critical habitat are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

We also considered potential effects of seafloor device use on the essential features of Gulf sturgeon designated critical habitat. The placement of seafloor devices on the seafloor within areas of critical habitat in the Panama City OPAREA within one mile from shore may affect the abundance of prey items (e.g., such as amphipods, lancelets, polychaetes, gastropods, ghost shrimp, isopods, mollusks and/or crustaceans) for sub adult and adult life stages of Gulf sturgeon within the immediate vicinity of the seafloor device. However, the use of seafloor devices within a particular area would be temporary (days to weeks) and the amount of prey items impacted during that short timeframe would be negligible compared to the remaining amount found in adjacent habitats that would be unaffected by the activities. For this reason, we conclude that the effect of seafloor devices on prey resources in designated critical habitat for Gulf sturgeon is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

In conclusion, we determined that the potential effect of Navy explosive and seafloor device use on the biological feature of Gulf sturgeon designated critical habitat defined by abundant food items in marine and nearshore habitats is insignificant. For this reason, Navy explosive and seafloor device use is not likely to adversely affect Gulf sturgeon designated critical habitat and Gulf sturgeon designated critical habitat will not be considered further in this opinion.

7.2 Species and Critical Habitat Likely to be Adversely Affected

This section examines the status of each species that are likely to be adversely affected by the proposed action. The status includes the existing level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution," which is part of the jeopardy determination as described in 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register, status reviews, recovery plans, and on NMFS' website: (https://www.fisheries.noaa.gov/species-directory/threatened-endangered), among others.

This section also examines the condition of critical habitat throughout the designated area (such as various coastal and marine environments that make up the designated area) and discusses the condition and current function of designated critical habitat, including the PBFs that contribute to that conservation value of the critical habitat.

7.2.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 20).

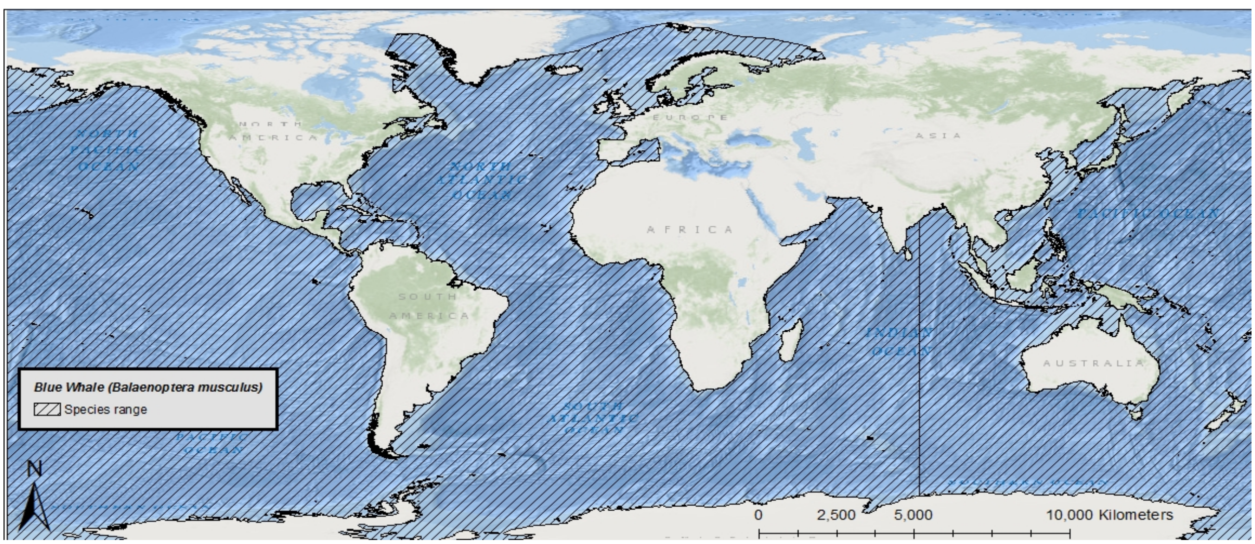


Figure 20. Map identifying the range of the endangered blue whale.

Blue whales are the largest animal on earth and distinguishable from other whales by a long-body and comparatively slender shape, a broad, flat "rostrum" when viewed from above, proportionally smaller dorsal fin, and are a mottled gray color that appears light blue when seen through the water. Most experts recognize at least three subspecies of blue whale, *B. m. musculus*, which occurs in the Northern Hemisphere, *B. m. intermedia*, which occurs in the Southern Ocean, and *B. m. brevicauda*, a pygmy species found in the Indian Ocean and South Pacific. The blue whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 1998), recent stock assessment reports (Carretta et al. 2017; Hayes et al. 2017; Muto et al. 2017), the status review (COSEWIC 2002), and the scientific literature were used to summarize the life history, population dynamics and status of the species as follows.

7.2.1.1.1 Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of 10 to 12 months, and calves nurse for six to seven months. Blue whales reach sexual maturity between five and 15 years of age with an average calving interval of two to three years. They winter at low latitudes, where they mate, calve and nurse, and summer at high latitudes, where they feed. Blue whales forage almost exclusively on krill and can eat approximately 3,600 kilograms daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 m.

7.2.1.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the blue whale.

The global, pre-exploitation estimate for blue whales is approximately 181,200 (IWC 2007). Current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC 2007). Blue whales are separated into populations by ocean basin in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. There are three stocks of blue whales designated in U.S. waters: the Eastern North Pacific Ocean [current best estimate N = 1,647 N_{min} = 1,551; (Calambokidis and Barlow 2013)], Central North Pacific Ocean (N = 81 N_{min} = 38), and Western North Atlantic Ocean (N = 400 to 600 N_{min} = 440). In the Southern Hemisphere, the latest abundance estimate for Antarctic blue whales is 2,280 individuals in 1997/1998 [95 percent confidence intervals 1,160 to 4,500 (Branch 2007)].

Current estimates indicate a growth rate of just under three percent per year for the eastern North Pacific stock (Calambokidis et al. 2009). An overall population growth rate for the species or growth rates for the two other individual U.S. stocks are not available at this time. In the Southern Hemisphere, population growth estimates are available only for Antarctic blue whales, which estimate a population growth rate of 8.2 percent per year (95 percent confidence interval 1.6 to 14.8 percent, Branch 2007).

Little genetic data exist on blue whales globally. Data from Australia indicates that at least populations in this region experienced a recent genetic bottleneck, likely the result of commercial whaling, although genetic diversity levels appear to be similar to other, non-threatened mammal species (Attard et al. 2010). Consistent with this, data from Antarctica also demonstrate this bottleneck but high haplotype diversity, which may be a consequence of the recent timing of the bottleneck and blue whales long lifespan (Sremba et al. 2012). Data on genetic diversity of blue whales in the Northern Hemisphere are currently unavailable. However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations at low densities (<100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

In general, blue whale distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore. In the North Atlantic Ocean, the blue whale range extends from the subtropics to the Greenland Sea. They are most frequently sighted in waters off eastern Canada with a majority of sightings taking place in the Gulf of St. Lawrence. In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off the Aleutian Islands and the Bering Sea. In the northern Indian Ocean, there is a "resident" population of blue whales with sightings being reported from the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca. In the Southern Hemisphere, distributions of subspecies (*B. m. intermedia* and *B. m. brevicauda*) seem to be segregated. The subspecies *B. m. intermedia* occurs in relatively high latitudes south of the "Antarctic Convergence" (located between 48°S and 61°S latitude) and close to the ice edge. The subspecies *B. m. brevicauda* is typically distributed north of the Antarctic Convergence.

7.2.1.3 Vocalizations and Hearing

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 Hz) signals (Thomson and Richardson 1995), with a range of 12 to 400 Hz and dominant energy in the infrasonic range of 12 to 25 Hz (Ketten 1998; McDonald et al. 2001; McDonald et al. 1995; Mellinger and Clark 2003). Vocalizations are predominantly songs and calls.

Calls are short-duration sounds (two to five seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (20 to 80 Hz), with seasonally variable occurrence. Blue whale calls have high acoustic energy, with reports of source levels ranging from 180 to 195 dB re: 1 μPa at 1 m (Aburto et al. 1997; Berchok et al. 2006; Clark and Gagnon 2004; Cummings and Thompson 1971b; Ketten 1998; McDonald et al. 2001; Samaran et al. 2010). Calling rates of blue whales tend to vary based on feeding behavior. For example, blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds then during migration (Burtenshaw et al. 2004). Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Oleson et al. (2007c) reported higher calling rates in shallow diving (less than 30 m whales), while deeper diving whales (greater than 50 m) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (McDonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005; Thompson et al. 1996), some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the North Atlantic Ocean have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Berchok et al. 2006; Mellinger and Clark 2003; Samaran et al. 2010). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific Ocean have also been reported (Stafford et al. 2001); however, some overlap in calls from the geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005). In Southern California, blue whales produce three known call types: Type A, B, and D. B calls are stereotypic of blue whale population found in the eastern North Pacific (McDonald et al. 2006b) and are produced exclusively by males and associated with mating behavior (Oleson et al. 2007a). These calls have long durations (20 seconds) and low frequencies (10 to 100 Hz); they are produced either as repetitive sequences (song) or as singular calls. The B call has a set of harmonic tonals, and may be paired with a pulsed Type A call. D calls are produced in highest numbers during the late spring and early summer, and in diminished numbers during the fall, when A-B song dominates blue whale calling (Hildebrand et al. 2011; Hildebrand et al. 2012; Oleson et al. 2007c).

Blue whale songs consist of repetitively patterned vocalizations produced over time spans of minutes to hours or even days (Cummings and Thompson 1971b; McDonald et al. 2001). The songs are divided into pulsed/tonal units, which are continuous segments of sound, and phrases, repeated in combinations of one to five units (Mellinger and Clark 2003; Payne and Mcvay 1971). Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al. 1998), and have only been attributed to males (McDonald et al. 2001; Oleson et al. 2007a). Worldwide, songs are showing a downward shift in frequency (McDonald et al. 2009). For example, a comparison of recording from November 2003 and November 1964 and 1965 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 Hz compared to approximately 22.5 Hz in 1964 and 1965, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al. 2006b). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in seven of the world’s 10 known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist but none have emerged as the probable cause.

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources) (Edds-Walton 1997; Oleson et al. 2007b; Payne and Webb. 1971; Thompson et al. 1992). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30 to 90 Hz calls are associated with socialization and may be displays by males based upon call seasonality and structure. The low frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long distance communication occurs (Edds-Walton 1997; Payne and Webb. 1971). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hz (Croll et al. 2001; Oleson et al. 2007c; Stafford and Moore 2005). In terms of functional hearing capability, blue whales belong to the low frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA 2016b).

7.2.1.4 Status

The blue whale is endangered as a result of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were harvested from the late nineteenth to mid-twentieth centuries. In the North Pacific Ocean, at least 9,500 whales were killed between 1910 and 1965. Commercial whaling no longer occurs, but blue whales are threatened by vessel strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

7.2.1.5 Critical Habitat

No critical habitat has been designated for the blue whale.

7.2.1.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover blue whale populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 1998 Final Recovery Plan for the Blue whale for complete down listing/delisting criteria for each of the following recovery goals.

- Determine stock structure of blue whale populations occurring in U.S. waters and elsewhere
- Estimate the size and monitor trends in abundance of blue whale populations
- Identify and protect habitat essential to the survival and recovery of blue whale populations
- Reduce or eliminate human-caused injury and mortality of blue whales
- Minimize detrimental effects of directed vessel interactions with blue whales
- Maximize efforts to acquire scientific information from dead, stranded, and entangled blue whales
- Coordinate state, federal, and international efforts to implement recovery actions for blue whales
- Establish criteria for deciding whether to delist or down list blue whales

7.2.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachonica* (a pygmy form) in the Southern Hemisphere (Figure 21).

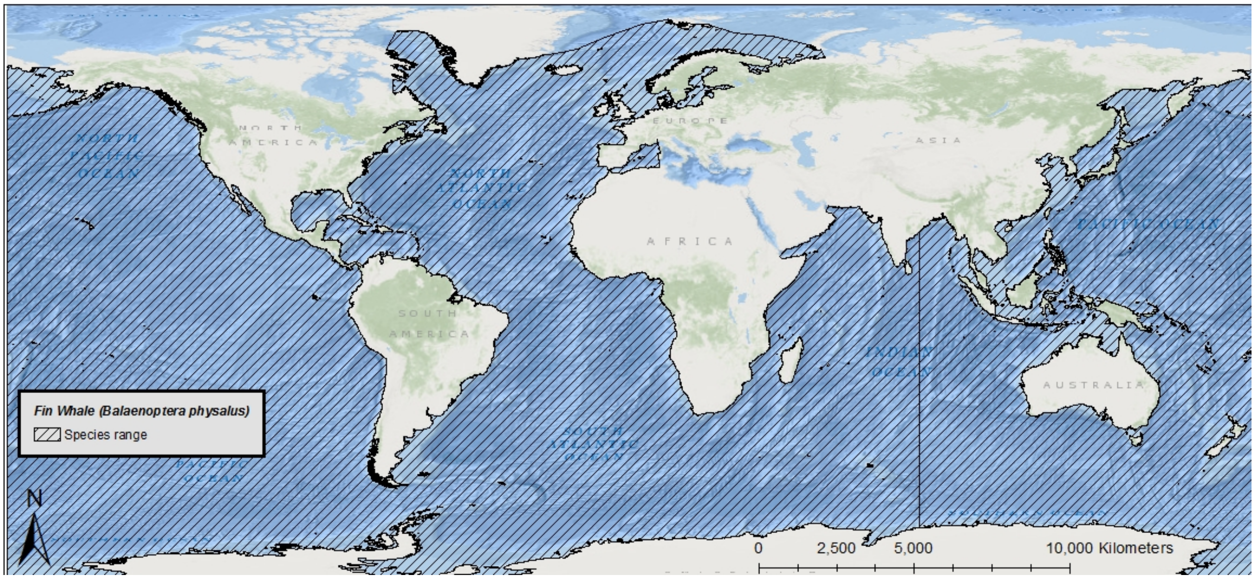


Figure 21. Map identifying the range of the endangered fin whale.

Fin whales are distinguishable from other whales by a sleek, streamlined body, with a V-shaped head, a tall falcate dorsal fin, and a distinctive color pattern of a black or dark brownish-gray body and sides with a white ventral surface. The lower jaw is gray or black on the left side and creamy white on the right side. The fin whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010b), recent stock assessment reports (Carretta et al. 2017; Hayes et al. 2017; Muto et al. 2017), the status review (NMFS 2011d), and the scientific literature were used to summarize the life history, population dynamics and status of the species as follows.

7.2.2.1 Life History

Fin whales can live, on average, 80 to 90 years. They have a gestation period of less than one year, and calves nurse for six to seven months. Sexual maturity is reached between six and 10 years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas. Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lice.

7.2.2.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the fin whale.

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi and Wada 1974). In the North Atlantic Ocean, at least 55,000 fin whales were killed between 1910 and 1989. Approximately 704,000 fin whales were killed in the Southern Hemisphere from 1904 to 1975. Of the three to seven stocks thought to occur in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in U.S. waters, where NMFS' best estimate of abundance is 1,618 individuals (N_{min}=1,234); however, this may be an underrepresentation as the entire range of the stock was not surveyed (Palka 2012). There are three stocks in U.S. Pacific Ocean waters: Northeast Pacific (minimum 1,368 individuals), Hawaii (approximately 58 individuals, N_{min}=27) and California/Oregon/Washington (approximately 9,029 individuals, N_{min}=8,127) (Nadeem et al. 2016). The International Whaling Commission (IWC) also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013). Abundance data for the Southern Hemisphere stock are limited; however, there were assumed to be somewhat more than 15,000 in 1983 (Thomas et al. 2016).

Current estimates indicate approximately 10,000 fin whales in U.S. Pacific Ocean waters, with an annual growth rate of 4.8 percent in the Northeast Pacific stock and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al. 2016). Overall population growth rates and total abundance estimates for the Hawaii stock, China Sea stock, western North Atlantic stock, and Southern Hemisphere fin whales are not available at this time.

Archer et al. (2013) recently examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial DNA genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean, which may indicate a revision of the subspecies delineations is warranted. Generally speaking, haplotype diversity was found to be high both within ocean basins, and across. Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some populations having small abundance estimates, the species may persist long-term and be somewhat protected from substantial environmental variance and catastrophes.

There are over 100,000 fin whales worldwide, occurring primarily in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere where they appear to be reproductively isolated. The availability of prey, sand lice in particular, is thought to have had a strong influence on the distribution and movements of fin whales.

7.2.2.3 Vocalizations and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hz range (Edds 1988; Thompson et al. 1992; Watkins 1981b; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18 to 35 Hz range, but only males are known to produce these (Clark et al. 2002; Patterson and Hamilton 1964). The most typically recorded call is a 20 Hz pulse lasting about one second, and reaching source levels of 189 ±4 dB re: 1 μPa at 1 m (Charif et al. 2002; Clark et al. 2002; Edds 1988; Richardson et al. 1995c; Sirovic et al. 2007; Watkins 1981b; Watkins et al. 1987). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 Hz), and can be repeated over the course of many hours (Watkins et al. 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Richardson et al. (1995c) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981b; Watkins et al. 1987); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al. 2002). In Southern California, the 20 Hz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (U.S. Navy 2010; U.S. Navy 2012). An additional fin whale sound, the 40 Hz call described by Watkins (1981b), was also frequently recorded, although these calls are not as common as the 20 Hz fin whale pulses. Seasonality of the 40 Hz calls differed from the 20 Hz calls, since 40 Hz calls were more prominent in the spring, as observed at other sites across the northeast Pacific Ocean (Sirovic et al. 2012). Source levels of Eastern Pacific Ocean fin whale 20 Hz calls has been reported as 189 ± 5.8 dB re: 1 μPa at 1 m (Weirathmueller et al. 2013). Some researchers have also recorded moans of 14 to 118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34 to 150 Hz, and songs of 17 to 25 Hz (Cummings and Thompson 1994; Edds 1988; Watkins 1981b). In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 μPa at 1 m (see also Clark and Gagnon 2004; as compiled by Erbe 2002). The source depth of calling fin whales has been reported to be about 50 m (Watkins et al. 1987). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20-Hz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Thompson et al. 1992; Watkins et al. 1987).

Although their function is still in doubt, low frequency fin whale vocalizations travel over long distances and may aid in long distance communication (Edds-Walton 1997; Payne and Webb. 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpback whales (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999). Also, it has been suggested that some fin whale sounds may function for long range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c). This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 Hz and 12 kHz and a maximum sensitivity to sounds in the 1 to 2 kHz range. In terms of functional hearing capability, fin whales belong to the low-frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA 2016b).

7.2.2.4 Status

The fin whale is endangered as a result of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. Fin whales may be killed under "aboriginal subsistence whaling" in Greenland, under Japan's scientific whaling program, and Iceland's formal objection to the International Whaling Commission's ban on commercial whaling. Additional threats include vessel strikes, reduced prey availability due to overfishing or climate change, and sound. The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

7.2.2.5 Critical Habitat

No critical habitat has been designated for the fin whale.

7.2.2.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover fin whale populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 2010 Final Recovery Plan for the fin whale for complete downlisting/delisting criteria for both of the following recovery goals.

- Achieve sufficient and viable population in all ocean basins.
- Ensure significant threats are addressed.

7.2.3 Bryde's Whales – Gulf of Mexico Subspecies

Bryde's whales in the Gulf of Mexico are genetically distinct from other Bryde's whales worldwide (including the subspecies of *B. e. edeni* and *B. e. brydei*). Bryde's whales are found in tropical and subtropical waters worldwide and the smaller species are typically found in coastal and continental shelf waters. The Gulf of Mexico subspecies of Bryde's whale is the only known baleen whale to inhabit the Gulf of Mexico year-round. They are consistently found in the northeastern Gulf of Mexico in the De Soto Canyon area between the 100 m and 300 m depth contours, where LaBrecque et al. (2015) designated a Biologically Important Area (BIA) for the species (Figure 22).

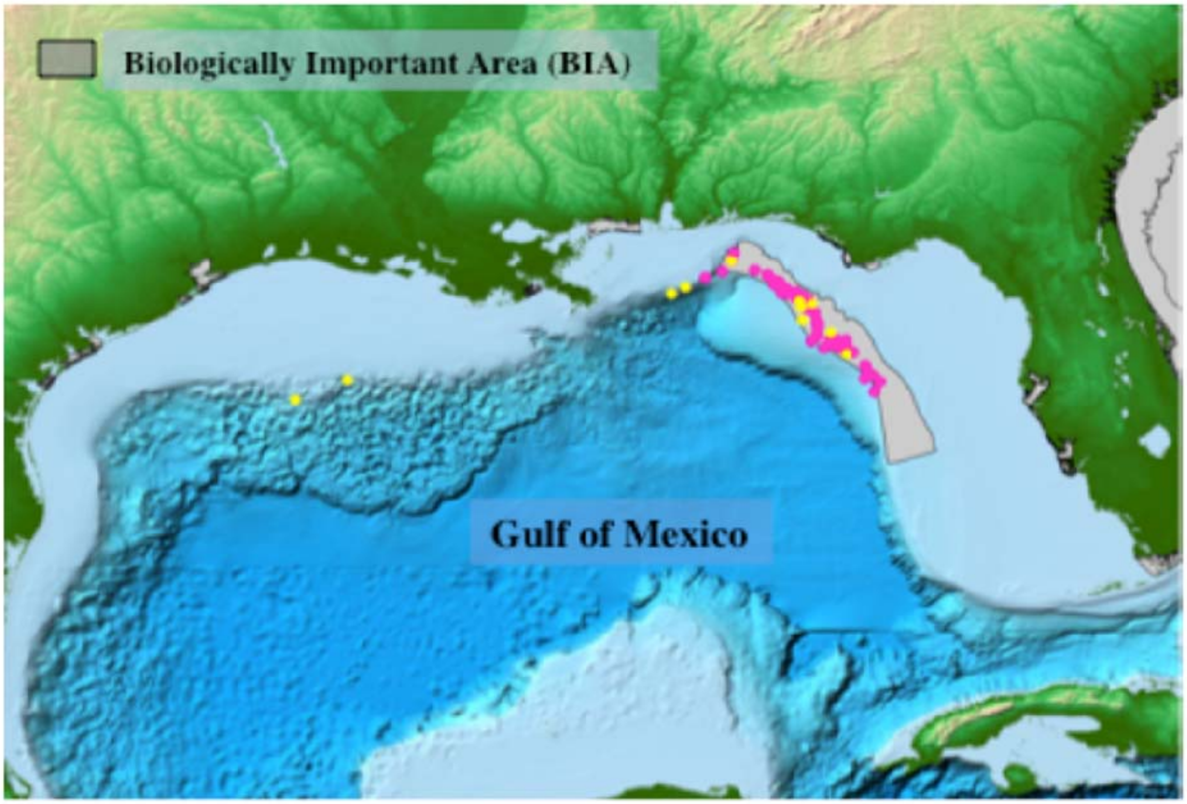


Figure 22. Map identifying sightings of Bryde's whales (pink) and unidentified balaenopterid whales (yellow) during shipboard and aerial surveys between 1989 and 2015 in the northern Gulf of Mexico, with respect to a Biologically Important Area (LaBrecque et al. 2015; Rosel 2016).

Bryde's whales are baleen whales that typically grow to lengths of 40 to 55 ft (13 to 16.5 m). According to Rice (1998), adult *B. e. edeni* rarely exceed 37 ft (11.5 m) total length and adult *B. e. brydei* reach approximately 46 to 49 ft (14 to15 m). Rosel and Wilcox (2014) summarized body length information of stranded Bryde's whales from the Gulf of Mexico and concluded that they may have a size range intermediate to the currently recognized subspecies. The species has a large, falcate dorsal fin, a streamlined body shape, and a pointed, flat rostrum. There are three ridges on the dorsal surface of the rostrum that distinguish it from other similar-looking species, such as the sei whale (Rosel 2016). Bryde's whales have a counter-shaded color that is fairly uniformly-dark dorsally and light to pinkish ventrally. Gulf of Mexico Bryde's whales were proposed for listing as a separate subspecies under the ESA on December 8, 2016.

Information available from the status review (Rosel 2016), the proposed listing, and the scientific literature were used to summarize the life history, population dynamics, and status of the species as follows.

7.2.3.1 Life History

Little is known about the Gulf of Mexico Bryde's whale subspecies' life history compared to Bryde's whales more generally and worldwide. The life expectancy of Bryde's whales is unknown. Other stocks of this species have a gestation period of 11 to 12 months, and give birth to a single calf, which is nursed for six to 12 months. Age of sexual maturity is not known for Gulf of Mexico Bryde's whales specifically, but Bryde's whales are thought to be sexually mature at eight to 13 years. Peak breeding and calving probably occurs in the fall. Females breed every second year. Bryde's whales, unlike other baleen whales, are not known to make long foraging migrations (Figueiredo et al. 2014). The Gulf of Mexico subspecies is a year-round resident of the Gulf of Mexico. Bryde's whales are known to dive to over 200 m depth to feed on small schooling fish (e.g., anchovy, sardine, mackerel, and herring) and crustaceans and their occurrence is thought to be determined by prey abundance (Kerosky et al. 2012; Rosel 2016). They exhibit a typical diel dive pattern, with deep dives in the daytime, and shallow dives at night. They are observed in small groups, pairs or solitary and reportedly seem curious about ships (Lodi et al. 2015; Rosel 2016; Tershy 1992).

7.2.3.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Gulf of Mexico Bryde's.

The Gulf of Mexico Bryde's whale population is very small; the most recent estimate from 2009 places the population size at 33 individuals (Waring 2016). A second habitat-based density estimate by Roberts et al. (2016) that incorporated visual survey data from 1992 to 2009 estimated 44 individuals (Rosel 2016). Given the best available scientific information and allowing for the uncertainty of Bryde's whale occurrence in non-U.S. waters of the Gulf of Mexico, most likely less than 100 individuals exist (Rosel 2016). There is no population trend information available for the Gulf of Mexico Bryde's whale.

Genetic diversity within the Gulf of Mexico Bryde's whale population is very low. Genetic analysis of Bryde's whale samples from the Gulf of Mexico found only two mitochondrial DNA control region haplotypes in the first 375 base pairs of the control region (compared to five haplotypes for North Atlantic right whales and 51 in fin whales across the same control region sequence) (Rosel and Wilcox 2014). Examination of 42 nuclear microsatellite loci found that 25 (60 percent) were monomorphic, meaning no genetic variability was seen for the 21 Gulf of Mexico Bryde's whales sampled (Rosel 2016).

Phylogenetic reconstruction using the control region and all published Bryde's whale sequences reveal that the Gulf of Mexico Bryde's whale's haplotypes are evolutionarily distinct from the other two recognized subspecies of Bryde's whale as the two subspecies are from each other. In addition, the Gulf of Mexico Bryde's whale is more genetically differentiated from the two recognized subspecies than is the sei whale, which is an entirely different species (Rosel and Wilcox 2014).

Bryde's whales are consistently found in the De Soto Canyon area, and there have also been sightings at 302 and 309 m depth in this region and west of Pensacola, Florida (Figure 22). Given this, the core area inhabited by the species is probably best described out to the 400 m depth contour and to Mobile Bay, Alabama, to provide some buffer around the deeper water sightings and to include all sighting locations in the northeastern Gulf of Mexico, respectively (Rosel 2016). Whaling records indicate the historical distribution of Bryde's whales in the Gulf of Mexico may have been much broader than it is currently and included the north-central and southern Gulf of Mexico.

7.2.3.3 Vocalization and Hearing

Bryde's whales produce low-frequency tonal and broadband calls for communication, navigation, and reproduction (Richardson et al. 1995c). Like other balaenopterids, Bryde's whales have distinctive calls depending on geographic regions that may be useful for delineating subspecies or populations (Figueiredo 2014; Rosel 2016; Širović et al. 2014). Based on data presented in Širović et al. (2014) and Rice et al. (2014), the calls by the Gulf of Mexico Bryde's whale are consistent with, but different from those previously reported for Bryde's whales worldwide. These unique acoustic signatures support the genetic analyses identifying the Gulf of Mexico Bryde's whale as an evolutionary distinct unit (Rosel and Wilcox 2014).

Direct studies of Bryde's whale hearing have not been conducted, but it is assumed that they can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c). This suggests Gulf of Mexico Bryde's whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In terms of functional hearing capability, Gulf of Mexico Bryde's whales belong to the low-frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA 2016b).

7.2.3.4 Status

Historically, commercial whaling did occur in the Gulf of Mexico, but the area was not considered prime whaling grounds. Bryde's whales were not specifically targeted by commercial whalers, but the "finback whales" which were caught between the mid-1700s and late 1800s were likely Bryde's whales (Reeves et al. 2011). The Bryde's whale status review identified 27 possible threats to Gulf of Mexico Bryde's whales, with the following four being the most significant: (1) sound, (2) vessel collisions; (3) energy exploration; (4) oil spills and oil spill response. Noise from shipping traffic and seismic surveys in the region may impact Gulf of Mexico Bryde's whales' ability to communicate. Vessel traffic from commercial shipping and the oil and gas industry also poses a risk of vessel strike for Gulf of Mexico Bryde's whales. Entanglement from fishing gear is also a threat, and several fisheries operate within the range of the species. The Deepwater Horizon oil spill severely impacted Bryde's whales in the Gulf of Mexico, with an estimated 17 percent of the population killed, 22 percent of females exhibiting reproductive failure, and 18 percent of the population suffering adverse health effects (DWHTrustees 2016). Because the Gulf of Mexico Bryde's whale population is so small size and has low genetic diversity, it is highly susceptible to further perturbations.

7.2.3.5 Critical Habitat

No critical habitat has been designated for Gulf of Mexico Bryde's whales as the species is currently proposed for listing under the ESA.

7.2.3.6 Recovery Plan

No Recovery Plan has been prepared for Gulf of Mexico Bryde's whales as the species is currently proposed for listing under the ESA.

7.2.4 North Atlantic Right Whale

The North Atlantic right whale is a narrowly distributed baleen whale found in temperate and sub-polar latitudes in the North Atlantic Ocean (Figure 23). Today they are mainly found in the Western North Atlantic, but have been historically recorded south of Greenland and in the Denmark straight, as well as in Eastern North Atlantic waters (Kraus and Rolland 2007).

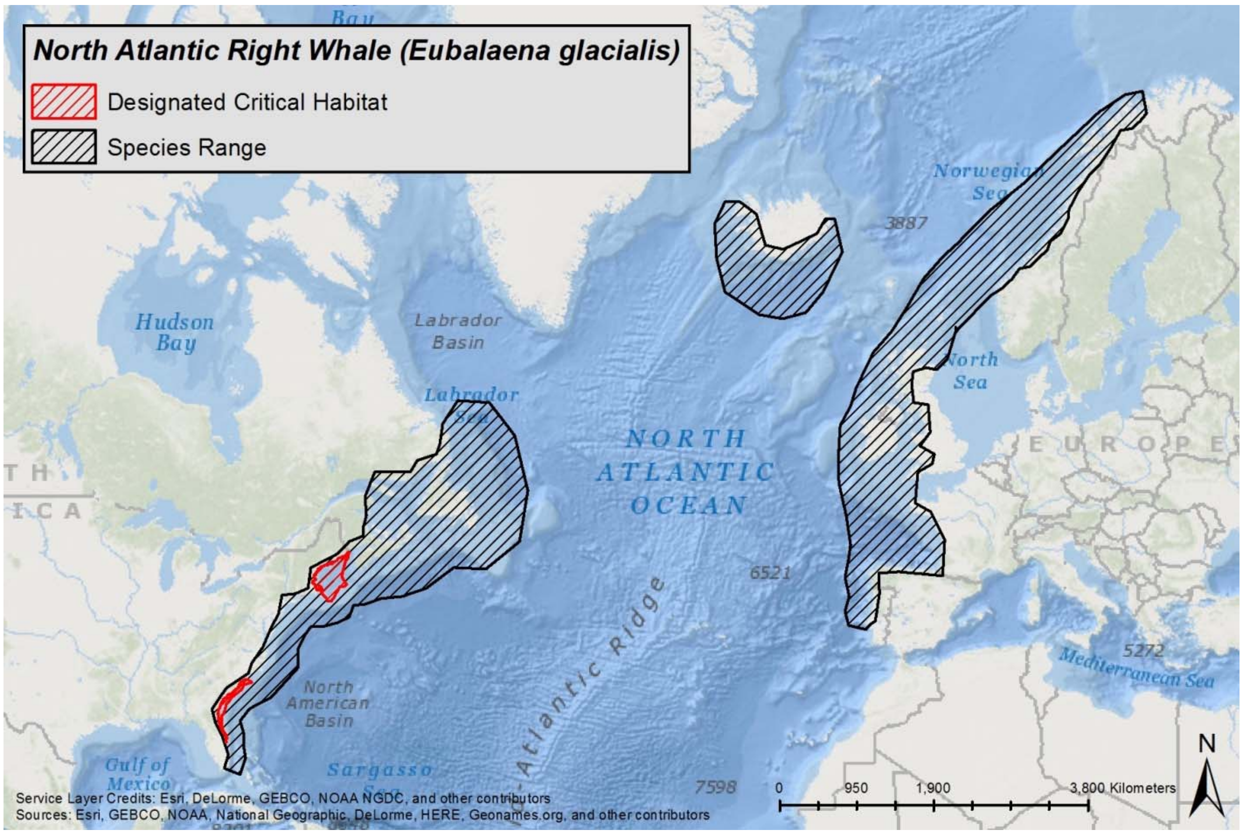


Figure 23: Map identifying the approximate historic range and currently designated U.S. critical habitat of the North Atlantic right whale.

The North Atlantic right whale is distinguished by its stocky body and lack of a dorsal fin. The species was originally listed as endangered on December 2, 1970.

We used information available in the most recent five-year review (NMFS 2017b), the most recent stock assessment report (Hayes et al. 2017), and the scientific literature to summarize the species, as follows.

7.2.4.1 Life history

The maximum lifespan of North Atlantic right whales is unknown, but one individual is thought to have reached around 70 years of age (Hamilton et al. 1998; Kenney 2009). Previous modelling efforts suggest that in 1980, females had a life expectancy of approximately 52 years of age, which was twice that of males at the time (Fujiwara and Caswell 2001). However, due to reduced survival probability (Caswell et al. 1999), in 1995 female life expectancy was estimated to have declined to approximately 15 years, with males having a slightly higher life expectancy into the 20s (Fujiwara and Caswell 2001). A recent study demonstrated that females have substantially higher mortality than males (Pace et al. 2017a), and as a result, also have substantially shorter life expectancies.

Gestation is approximately one year, after which calves typically nurse for around a year (Kenney 2009; Kraus et al. 2007; Lockyer 1984). After weaning calves, females typically undergo a 'resting' year before becoming pregnant again, presumably because they need time to recover from the energy deficit experienced during lactation (Fortune et al. 2013; Fortune et al. 2012; Pettis et al. 2017b). From 1983 to 2005, annual average calving intervals ranged from three to 5.8 years (overall average of 4.23 years) (Knowlton et al. 1994; Kraus et al. 2007). Between 2006 and 2015, annual average calving intervals continued to vary within this range, but in 2016 and 2017 longer calving intervals were reported (6.3 to 6.6 years in 2016 and 10.2 years in 2017; Pettis and Hamilton 2015; Pettis and Hamilton 2016; Pettis et al. 2017a; Surrey-Marsden et al. 2017). Females have been known to give birth as young as five years old, but the mean age of first partition is about 10 years old (Kraus et al. 2007).

Pregnant North Atlantic right whales migrate south, through the mid-Atlantic region of the United States, to low latitudes during late fall where they overwinter and give birth in shallow, coastal waters (Kenney 2009). During spring, these females migrate back north with their new calves to high latitude foraging grounds where they feed on large concentrations of copepods, primarily *Calanus finmarchicus* (NMFS 2017b). Some non-reproductive North Atlantic right whales (males, juveniles, non-reproducing females) also migrate south along the mid-Atlantic region, although at more variable times throughout the winter, while others appear to not migrate south, and instead remain in the northern feeding grounds year-round or go elsewhere (Bort et al. 2015; Morano et al. 2012; NMFS 2017b). Little is known about North Atlantic right whale habitat use in the mid-Atlantic, but recent acoustic data indicate near year-round presence of at least some whales off the coasts of New Jersey, Virginia, and North Carolina (Davis et al. 2017a; Hodge et al. 2015; Salisbury et al. 2016; Whitt et al. 2013). While it is generally not known where North Atlantic right whales mate, some evidence suggests that mating may occur in the northern feeding grounds (Cole et al. 2013; Matthews et al. 2014).

7.2.4.2 Population dynamics

The following is a discussion of the species' population and its variance over time. This section includes a discussion of abundance, population growth rate and vital rates, genetic diversity, and spatial distribution as it relates to the North Atlantic right whale.

There are currently two recognized populations of North Atlantic right whales, an eastern and a western population. In the eastern North Atlantic, sightings of right whales are rare and the population may be functionally extinct (Best et al. 2001). In the western North Atlantic, there were estimated to be 458 in November 2015 based on a Bayesian mark–recapture open population model, which accounts for individual differences in the probability of being photographed (95 percent credible intervals 444–471, Pace et al. 2017a). While photographic data for 2016 are still being processed, using this same Bayesian methodology with the available data as of September 1, 2017, gave an estimate of 451 individuals for 2016 (Pettis et al. 2017a). Accurate pre-exploitation abundance estimates are not available for either population of the species. The western population may have numbered fewer than 100 individuals by 1935, when international protection for right whales came into effect (Kenney et al. 1995).

The western North Atlantic population demonstrated overall growth of 2.8 percent per year between 1990 to 2010, despite a decline in 1993 and no growth between 1997 and 2000 (Pace et al. 2017a). However, since 2010 the population has been in decline, with a 99.99 percent probability of a decline of just under one percent per year (Pace et al. 2017a). Between 1990 and 2015, survival rates appeared to be relatively stable, but differed between the sexes, with males having higher survivorship than females (males: 0.985 ± 0.0038; females: $0.968 + 0.0073$) leading to a male-biased sex ratio (approximately 1.46 males per female, Pace et al. 2017a). During this same period, calving rates varied substantially, with low calving rates coinciding with all three periods of decline or no growth (Pace et al. 2017a). On average, North Atlantic right whale calving rates are estimated to be roughly half that of southern right whales (*Eubalaena australis*) (Pace et al. 2017a), which are increasing in abundance (NMFS 2015b).

While data are not yet available to statistically estimate the population's trend beyond 2015, three lines of evidence indicate the population is still in decline. First, calving rates in 2016, 2017, and 2018 were low. Only five new calves were documented in 2017 (Pettis et al. 2017a), well below the number needed to compensate for expected mortalities (Pace et al. 2017a), and as of February 26, 2018, no new calves have been reported for 2018 (B. Zoodsma, NMFS, personal communication to E. Patterson, NMFS; February 26, 2018). Long-term photographic identification data indicate new calves rarely go undetected, so these years likely represent a continuation of the low calving rates that began in 2012 (Kraus et al. 2007; Pace et al. 2017a). Second, as noted above, the preliminary abundance estimates for 2016 is 451 individuals, down approximately 1.5 percent from 458 in 2015. Third, since June 2017, at least 17 North Atlantic right whales have died in what has been declared an Unusual Mortality Event[19], and at least one calf died prior to this in April 2017 (NMFS 2017b). Twelve whales died in Canada in the Gulf of St. Lawrence area, five off the New England coast of the United States, and one off the coast of the Virginia-North Carolina border. To date, three mortalities have been attributed to entanglement in fishing gear and five showed signs of blunt force trauma consistent with vessel strikes (Daoust et al. 2017; M. Hardy personal communication to D. Fauquier on October 5,

[19] http://www.nmfs.noaa.gov/pr/health/mmume/2017northatlanticrightwhaleume.html

2017; Pettis et al. 2017a). The remaining causes of death could not be, or have yet to be, determined.

Analysis of mtDNA from North Atlantic right whales has identified seven mtDNA haplotypes in the western North Atlantic (Malik et al. 1999; McLeod and White 2010). This is significantly less diverse than southern right whales and may indicate inbreeding (Hayes et al. 2017; Malik et al. 2000; Schaeff et al. 1997). While analysis of historic DNA taken from museum specimens indicates that the eastern and western populations were likely not genetically distinct, the lack of recovery of the eastern North Atlantic population indicates at least some level of population segregation (Rosenbaum et al. 1997; Rosenbaum et al. 2000). Overall, the species has low genetic diversity as would be expected based on its low abundance. However, analysis of 16th and 17th century whaling bones indicate this low genetic diversity may pre-date whaling activities (McLeod et al. 2010). Despite this, Frasier et al. (2013) recently identified a post-copulatory mechanism that appears to be slowly increasing genetic diversity among right whale calves.

Today, North Atlantic right whales are primarily found in the western North Atlantic, from their calving grounds in lower latitudes off the coast of the southeastern United States to their feeding grounds in higher latitudes off the coast of New England and Nova Scotia (Hayes et al. 2017). In recent years, there has been a shift in distribution in their feeding grounds, with fewer animals being seen in the Great South Channel and the Bay of Fundy and perhaps more animals being observed in the Gulf of Saint Lawrence and mid-Atlantic region (Daoust et al. 2017; Davis et al. 2017a; Hayes et al. 2017; Pace et al. 2017a). Very few individuals likely make up the population in the eastern Atlantic, which is thought to be functionally extinct (Best et al. 2001). However, in recent years, a few known individuals from the western population have been seen in the eastern Atlantic, suggesting some individuals may have wider ranges than previously thought (Kenney 2009).

7.2.4.3 Vocalization and Hearing

North Atlantic right whales vocalize during social interaction and likely to communicate over long distances (McCordic et al. 2016; Parks and Clark 2007; Parks et al. 2011b; Tyson et al. 2007). Calls among North Atlantic right whales are similar to those of other right whale species, and can be classified into six major call types: screams, gunshots, blows, upcalls, warbles, and downcalls (McDonald and Moore 2002; Parks et al. 2011b; Parks and Tyack 2005; Soldevilla et al. 2014). The majority of vocalizations occur in the 200 Hz to one kHz range with most energy being below one kHz, but there is large variation in frequency depending on the call type (Hatch et al. 2012; Parks and Tyack 2005; Trygonis et al. 2013; Vanderlaan et al. 2003). Source levels range from 137 to 192 dB re: 1 μPa at 1 m (rms), with gunshot calls having higher source levels as compared to other call types (Hatch et al. 2012; Parks and Tyack 2005; Trygonis et al. 2013). These levels are low compared to some other baleen whales, which may put North Atlantic right whales at greater risk of communication masking compared to other species (Clark et al. 2009b; Hatch et al. 2012). Individual calls typically have a duration of 0.04 to 1.5 seconds depending on the call type, and bouts of calls can last for several hours (Parks et al. 2012a; Parks and Tyack 2005; Trygonis et al. 2013; Vanderlaan et al. 2003).

Vocalizations vary by demographic and context. Upcalls are perhaps the most ubiquitous call type, being commonly produced by all age and sex classes (Parks et al. 2011b). Other non-stereotyped tonal calls (e.g., screams) are also produced by all age sex classes (Parks et al. 2011b) but have been primarily attributed to adult females (Parks and Tyack 2005). Warbles are thought to be produced by calves and may represent 'practice' screams (Parks and Clark 2007; Parks and Tyack 2005). Blows are associated with ventilation and are generally inaudible underwater (Parks and Clark 2007). Gunshots appear to be largely or exclusively male vocalizations and may be a form of vocal display (Parks and Clark 2007; Parks et al. 2005; Parks et al. 2011b). Downcalls have been less frequently recorded, and while it is not known if they are produced by specific age-sex classes, they have been recorded in various demographic make ups of surface-active groups (Parks and Tyack 2005).

All types of right whale calls have been recorded in surface-active groups, with smaller groups vocalizing more than larger groups and vocalization being more frequent in the evening, at night, and perhaps on the calving grounds (Matthews et al. 2001; Matthews et al. 2014; Morano et al. 2012; Parks and Clark 2007; Parks et al. 2012a; Salisbury et al. 2016; Soldevilla et al. 2014; Trygonis et al. 2013). Screams are usually produced within 10 m of the surface (Matthews et al. 2001). Upcalls have been detected nearly year-round in Massachusetts Bay, peaking in April (Mussoline et al. 2012). Individuals remaining in the Gulf of Maine through winter continue to call, showing a strong diel pattern of upcall and gunshot vocalizations from November through January possibly associated with mating (Bort et al. 2015; Matthews et al. 2014; Morano et al. 2012; Mussoline et al. 2012). Upcalls may be used for long distance communication (McCordic et al. 2016), including to reunite calves with mothers (Parks and Clark 2007; Tennessen and Parks 2016b). In fact, a recent study indicates they contain information on individual identity and age (McCordic et al. 2016). However, while upcalls are frequently heard on the calving grounds (Soldevilla et al. 2014), they are infrequently produced by mothers and calves here perhaps because the two maintain visual contact until calves are approximately three to four months of age (Parks and Clark 2007; Parks and Van Parijs 2015; Trygonis et al. 2013). North Atlantic right whales shift calling frequencies, particularly those of upcalls, and increase call amplitude over both long and short term periods due to exposure to vessel sound, which may limit their communication space by as much as 67 percent compared to historically lower sound conditions (Hatch et al. 2012; Parks and Clark 2007; Parks et al. 2007a; Parks et al. 2011a; Parks et al. 2012b; Parks et al. 2009; Tennessen and Parks 2016b).

There are no direct data on the hearing range of North Atlantic right whales, although they are considered to be part of the low frequency hearing group with a hearing range between 7 Hz and 35 kHz (NOAA 2016b). However, based on anatomical modeling, their hearing range is predicted to be from 10 Hz to 22 kHz with a functional range probably between 15 Hz to 18 kHz (Parks et al. 2007b).

7.2.4.4 Status

The North Atlantic right whale is listed under the ESA as endangered. Currently, none of its recovery goals (See Section 7.2.4.6 below) have been met (NMFS 2017b). With whaling now prohibited, the two major known human causes of mortality are vessel strikes and entanglement in fishing gear. Progress has been made in mitigating vessel strikes by regulating vessel speeds (78 FR 73726) (Conn and Silber 2013c) and through the establishment of the Early Warning System network, but entanglement in fishing gear remains a major threat (Kraus et al. 2016). From 1990 to 2010, the population experienced overall growth consistent with one of its recovery goals (See Section 7.2.4.6 below). However, the population is currently experiencing a Unusual Mortality Event that appears to be related to both vessel strikes and entanglement in fishing gear (Daoust et al. 2017). On top of this, recent modeling efforts indicate that low female survival, a male biased sex ratio, and low calving success are contributing to the population's current decline (Pace et al. 2017a). While there are likely a multitude of factors involved, low calving has been linked to poor female health (Rolland et al. 2016) and reduced prey availability (Meyer-Gutbrod and Greene 2014; Meyer-Gutbrod and Greene 2018). Furthermore, entanglement in fishing gear appears to have substantial health and energetic costs that affect both survival and reproduction (Pettis et al. 2017b; Robbins et al. 2015; Rolland et al. 2017; van der Hoop et al. 2017). In fact, there is evidence of a population wide decline in health since the early 1990s, the last time the population experienced a population decline (Rolland et al. 2016). Given this status, the species resilience to future perturbations is considered very low. Recent modelling efforts by Meyer-Gutbrod and Greene (2018) indicate that the species may decline towards extinction if prey conditions worsen, as predicted under future climate scenarios, and anthropogenic mortalities are not reduced (Grieve et al. 2017).

7.2.4.5 Critical Habitat

Critical habitat for right whales in the North Atlantic was designated in 1994 and expanded in 2016. Presently, North Atlantic designated critical habitat includes two major units, both of which occur within the action area: Unit 1 located in the Gulf of Maine and Georges Bank Region and Unit 2 located off the coast of North Carolina, South Carolina, Georgia, and Florida (Figure 23). Unit 1 consists of important foraging area and contains the following physical and biological features essential to the conservation of the species: the physical oceanographic conditions and structures of the Gulf of Maine and Georges Bank region that combine to distribute and aggregate the zooplankton species *C. finmarchicus* for right whale foraging, namely prevailing currents and circulation patterns, bathymetric features (basins, banks, and channels), oceanic fronts, density gradients, and temperature regimes; low flow velocities in Jordan, Wilkinson, and Georges Basins that allow diapausing *C. finmarchicus* to aggregate passively below the convective layer so that the copepods are retained in the basins; late stage *C. finmarchicus* in dense aggregations in the Gulf of Maine and Georges Bank region; and diapausing *C. finmarchicus* in aggregations in the Gulf of Maine and Georges Bank region. Unit 2 consists of an important calving area and contains the following physical and biological features essential to the conservation of the species: sea surface conditions associated with Force four or less on the Beaufort Scale, sea surface temperatures of 7 to 17 °Celsius, and water depths of six to 28 m, where these features simultaneously co-occur over contiguous areas of at least 231 NM^2 of ocean waters during the months of November through April.

7.2.4.6 Recovery Goals

See the 2005 updated Recovery Plan for the North Atlantic right whale for complete down-listing criteria for the following recovery goals:

- The population ecology (range, distribution, age structure, and gender ratios, etc.) and vital rates (age-specific survival, age-specific reproduction, and lifetime reproductive success) of right whales are indicative of an increasing population;
- The population has increased for a period of thirty-five years at an average rate of increase equal to or greater than two percent per year;
- None of the known threats to Northern right whales are known to limit the population's growth rate; and
- Given current and projected threats and environmental conditions, the right whale population has no more than a one percent chance of quasi-extinction in one hundred years.

7.2.5 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 24).

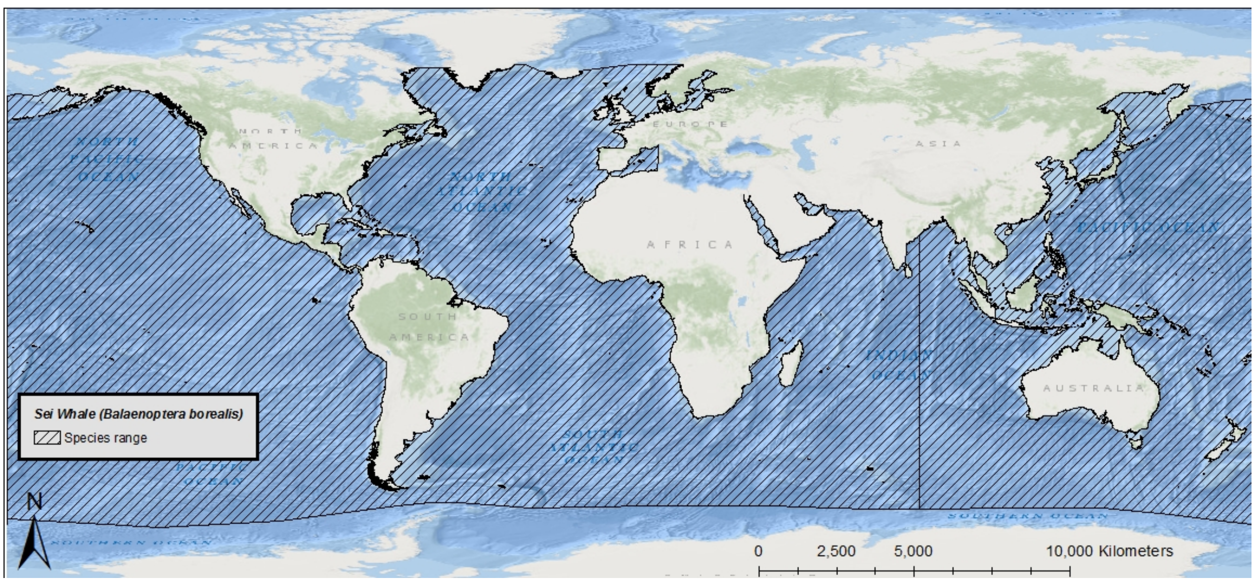


Figure 24. Map identifying the range of the endangered sei whale.

Sei whales are distinguishable from other whales by a long, sleek body that is dark bluish-gray to black in color and pale underneath, and a single ridge located on their rostrum. The sei whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2011e), recent stock assessment reports (Carretta et al. 2017; Hayes et al. 2017; Muto et al. 2017), the status review (NMFS 2012c), and the scientific literature were used to summarize the life history, population dynamics and status of the species as follows.

7.2.5.1 Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of 10 to 12 months, and calves nurse for six to nine months. Sexual maturity is reached between six and 12 years of age with an average calving interval of two to three years. Sei whales mostly inhabit continental shelf and slope waters far from the coastline. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed on a range of prey types, including: plankton (copepods and krill), small schooling fishes, and cephalopods.

7.2.5.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sei whale.

Two sub-species of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC 2016; Thomas et al. 2016). In the Southern Hemisphere, pre-exploitation abundance is estimated at 65,000 whales, with recent abundance estimated at 9,800 to 12,000 whales. Three relatively small stocks occur in U.S. waters: Nova Scotia (N=357, N_{min}=236), Hawaii (N=178, N_{min}=93), and Eastern North Pacific (N=519, N_{min}=374). There are no estimates of pre-exploitation abundance for the North Atlantic Ocean. Outside of U.S. waters, a shipboard sighting survey of Icelandic and Faroese waters produced an estimate of about 10,300 sei whales (Cattanach et al. 1993). Additionally in the North Atlantic, Macleod et al. (2005) reported an estimated 1,011 sei whales in waters off Scotland. Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

While some genetic data exist for sei whales, current samples sizes are small limiting our confidence in their estimates of genetic diversity (NMFS 2011e). However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations at low densities (less than 100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. All stocks of sei whales within U.S. waters are estimated to be below 500 individuals indicating they may be at risk of extinction due to inbreeding.

Sei whales are distributed worldwide, occurring in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere.

7.2.5.3 Vocalizations and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hz range with 1.5 second duration and tonal and upsweep calls in the 200 to 600 Hz range of one to three second durations (McDonald et al. 2005). Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 seconds, separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kHz (Thomson and Richardson 1995). Source levels of 189 ±5.8 dB re: 1 μPa at 1 m have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller et al. 2013).

Direct studies of sei whale hearing have not been conducted, but it is assumed that they can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c). This suggests sei whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In terms of functional hearing capability, sei whales belong to the low-frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA 2016b).

7.2.5.4 Status

The sei whale is endangered as a result of past commercial whaling. Now, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Current threats include vessel strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic sound. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

7.2.5.5 Critical Habitat

No critical habitat has been designated for the sei whale.

7.2.5.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sei whale populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 2011 Final Recovery Plan for the sei whale for complete downlisting/delisting criteria for both of the following recovery goals (NMFS 2011e).

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

7.2.6 Sperm Whales

The sperm whale is widely distributed and found in all major oceans (Figure 25).

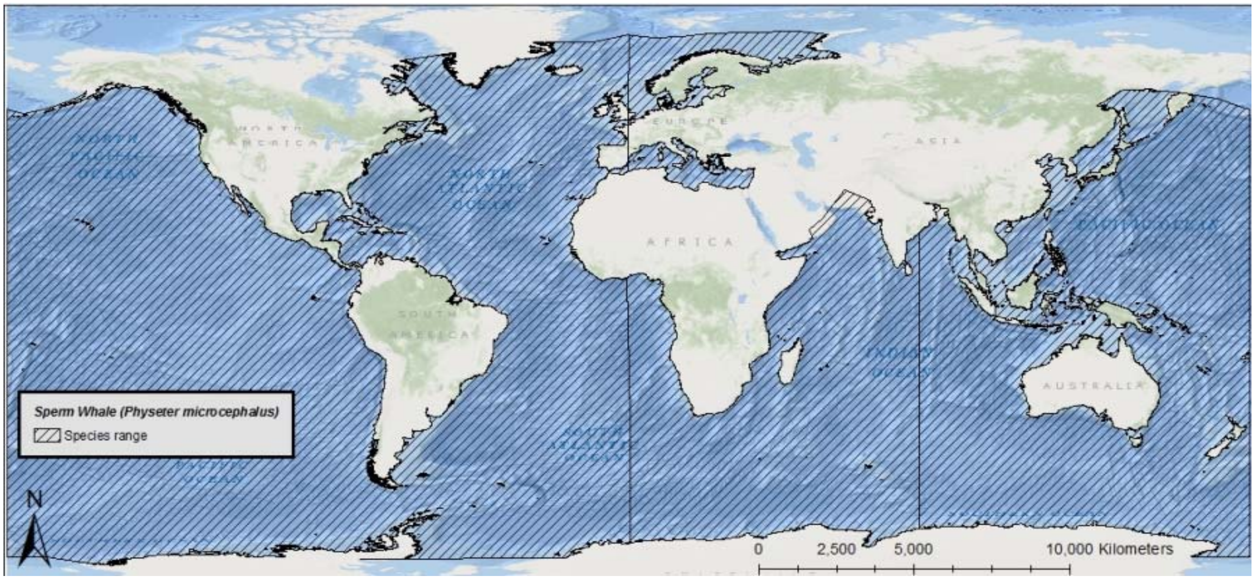


Figure 25. Map identifying the range of the endangered sperm whale.

The sperm whale is the largest toothed whale and distinguishable from other whales by its extremely large head, which takes up 25 to 35 percent of its total body length, and a single blowhole asymmetrically situated on the left side of the head near the tip. The sperm whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010a), recent stock assessment reports (Carretta et al. 2017; Hayes et al. 2017; Muto et al. 2017), the status review (NMFS 2015c), and the scientific literature were used to summarize the life history, population dynamics and status of the species as follows.

7.2.6.1 Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity is reached between seven and 13 years of age for females with an average calving interval of four to six years. Male sperm whales reach full sexual maturity in their twenties. Sperm whales mostly inhabit areas with a water depth of 600 m or more, and are uncommon in waters less than 300 m deep. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs).

7.2.6.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sperm whale.

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA listing. There are no reliable estimates for sperm whale abundance across the entire Atlantic Ocean. However, estimates are available for two of three U.S. stocks in the Atlantic Ocean, the Northern Gulf of Mexico stock, estimated to consist of 763 individuals (N_{min}=560) and the North Atlantic stock, underestimated to consist of 2,288 individuals (N_{min}=1,815). There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands stock. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 (95 percent confidence intervals 14,800 to 34,600) in 1993. Population estimates are also available for two of three U.S. stocks that occur in the Pacific, the California/Oregon/ Washington stock, estimated to consist of 2,106 individuals (N_{min}=1,332), and the Hawaii stock, estimated to consist of 3,354 individuals (N_{min}=2,539). There are insufficient data to estimate the population abundance of the North Pacific stock. We are aware of no reliable abundance estimates specifically for sperm whales in the South Pacific Ocean, and there is insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time.

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and Gyllensten 1998). Consistent with this, two studies of sperm whales in the Pacific Ocean indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). Furthermore, sperm whales from the Gulf of Mexico, the western North Atlantic Ocean, the North Sea, and the Mediterranean Sea all have been shown to have low levels of genetic diversity (Engelhaupt et al. 2009). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and 'Allee' effects, although the extent to which is currently unknown. Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. While both males and females can be found in latitudes less than 40°, only adult males venture into the higher latitudes near the poles.

7.2.6.3 Vocalizations and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hz to greater than 30 kHz (Watkins 1977) and dominant frequencies between 1 to 6 kHz and 10 to 16 kHz. Another class of sound, "squeals," are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al. 2007). The source levels of clicks can reach 236 dB re: 1 µPa at 1 m, although lower source level energy has been suggested at around 171 dB re: 1 µPa at 1 m (Goold and Jones 1995; Mohl et al. 2003; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kHz and 10 to 16 kHz (Goold and Jones 1995; Weilgart and Whitehead 1993). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hz and 1.7 kHz) with estimated source levels between 140 to 162 dB re: 1 µPa at 1 m (Madsen et al. 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Cranford 1992; Norris and Harvey 1972).

Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Miller et al. 2004; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997; Whitehead and Weilgart 1991). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Laplanche et al. 2005; Miller et al. 2004). Clicks are also used during social behavior and intragroup interactions (Weilgart and Whitehead 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Rendell and Whitehead 2004; Weilgart and Whitehead 1997). Research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects (Pavan et al. 2000; Weilgart and Whitehead 1997). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kHz and highest sensitivity to frequencies between 5 to 20 kHz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (André et al. 1997). Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 Hz and one kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 Hz and 160 kHz (NOAA 2016b).

7.2.6.4 Status

The sperm whale is endangered as a result of past commercial whaling. Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed; however, illegal hunting may occur. Continued threats to sperm whale populations include vessel strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and sound. The species' large population size shows that it is somewhat resilient to current threats.

7.2.6.5 Critical Habitat

No critical habitat has been designated for the sperm whale.

7.2.6.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sperm whale populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 2010 Final Recovery Plan for the sperm whale for complete downlisting/delisting criteria for both of the following recovery goals.

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

7.2.7 Green Sea Turtle – North Atlantic DPS

The green turtle is globally distributed and commonly inhabits nearshore and inshore waters, occurring throughout tropical, sub-tropical and, to a lesser extent, temperate waters. The North Atlantic DPS of green turtle is found in the North Atlantic Ocean and Gulf of Mexico (Figure 26).

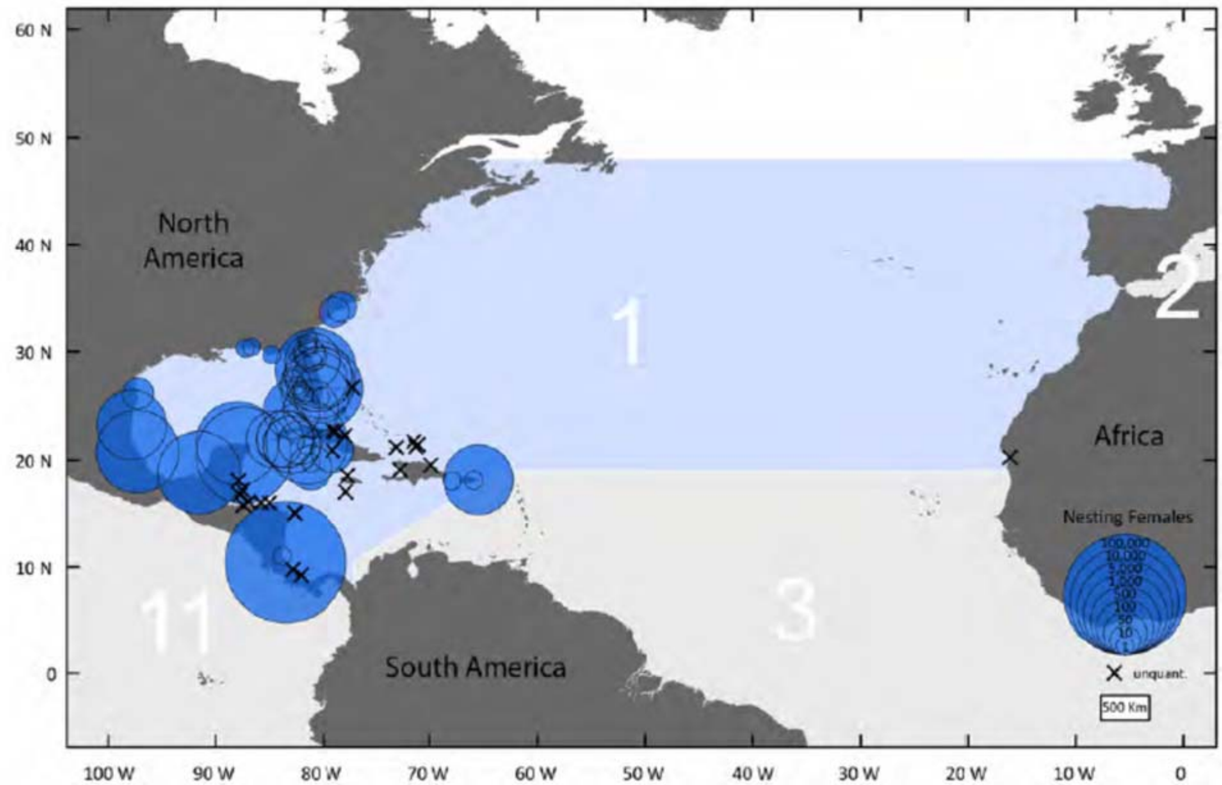


Figure 26. Geographic range of the North Atlantic DPS of green turtles, with location and abundance of nesting females (Seminoff et al. 2015a).

The green turtle is the largest of the hardshell sea turtles, growing to a weight of 158.8 kilograms and a straight carapace length of greater than one meter. The species was listed under the ESA on July 28, 1978 (43 FR 32800). The species was separated into two ESA-listing designations: endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed 11 DPSs of green turtles as threatened or endangered under the ESA. The North Atlantic DPS of green turtle is ESA-listed as threatened.

We used information available in the 2007 Five Year Review (NMFS and USFWS 2007a), the 2015 Status Review (Seminoff et al. 2015a), and the scientific literature to summarize the life history, population dynamics, and status of the species as follows.

7.2.7.1 Life History

Age at first reproduction for females is 20 to 40 years. Green turtles lay an average of three nests per season with an average of 100 eggs per nest. The remigration interval (i.e., return to natal beaches) is two to five years. Nesting occurs primarily on beaches with intact dune structure, native vegetation, and appropriate incubation temperatures during summer months. After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. Adult sea turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges, and other invertebrate prey.

7.2.7.2 Population Dynamics

The following discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the North Atlantic DPS of green turtle.

The green turtle occupies the coastal waters of over 140 countries worldwide; nesting occurs in more than 80 countries. Worldwide, nesting data at 464 sites indicate that 563,826 to 564,464 females nest each year (Seminoff et al. 2015a). Compared to other DPSs, the North Atlantic DPS exhibits the highest nester abundance, with approximately 167,424 females at 73 nesting sites (Figure 26), and available data indicate an increasing trend in nesting. The largest nesting site in the North Atlantic DPS is in Tortuguero, Costa Rica, which hosts 79 percent of nesting females for the DPS (Seminoff et al. 2015a).

Many nesting sites worldwide suffer from a lack of consistent, standardized monitoring, making it difficult to characterize population growth rates for a DPS. For the North Atlantic DPS of green turtle, the available data indicate an increasing trend in nesting. There are no reliable estimates of population growth rate for the DPS as a whole, but estimates have been developed at a localized level. Modeling by Chaloupka et al. (2008) using data sets for 25 years or more show the Florida nesting stock at the Archie Carr National Wildlife Refuge growing at an annual rate of 13.9 percent, and the Tortuguero, Costa Rica, population growing at 4.9 percent.

The North Atlantic DPS of green turtle has a globally unique haplotype, which was a factor in defining the discreteness of the population for the DPS. Evidence from mitochondrial DNA studies indicates that there are at least four independent nesting sub-populations in Florida, Cuba, Mexico, and Costa Rica (Seminoff et al. 2015a). More recent genetic analysis indicates that designating a new western Gulf of Mexico management unit might be appropriate (Shamblin et al. 2016).

The green turtle has a circumglobal distribution, occurring throughout nearshore tropical, sub-tropical and, to a lesser extent, temperate waters (Seminoff et al. 2015a). Green turtles from the

North Atlantic DPS range from the boundary of South and Central America (7.5° North, 77° West) in the south, throughout the Caribbean, the Gulf of Mexico, and the U.S. Atlantic coast to New Brunswick, Canada (48° North, 77° West) in the north. The range of the North Atlantic DPS then extends due east along latitudes 48° North and 19° North to the western coasts of Europe and Africa (Figure 26). Nesting occurs primarily in Costa Rica, Mexico, Florida, and Cuba.

7.2.7.3 Vocalization and Hearing

Sea turtles primarily detect low frequencies with typical hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Bartol and Ketten 2006b; Bartol et al. 1999b; Lenhardt 1994; Lenhardt 2002; Ridgway et al. 1969b). Piniak et al. (2016) found green turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz to 1,600 Hz (maximum sensitivity at 200 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Other studies have similarly found greatest sensitivities between 200 to 400 Hz for the green turtle with a range of 100 to 500 Hz (Bartol and Ketten 2006b; Ridgway et al. 1969b).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 to 4 kHz (Patterson 1966).

7.2.7.4 Status

Once abundant in tropical and sub-tropical waters, green turtles worldwide exist at a fraction of their historical abundance as a result of over-exploitation. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of sea turtles in foraging areas remain the three greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net, and trawl fisheries kill thousands of green turtles annually. Increasing coastal development (including beach erosion and re-nourishment, construction and artificial lighting) threatens nesting success and hatchling survival. On a regional scale, the different DPSs experience these threats as well, to varying degrees. Differing levels of abundance combined with different intensities of threats and effectiveness of regional regulatory mechanisms make each DPS uniquely susceptible to future perturbations.

Historically, green turtles in the North Atlantic DPS were hunted for food, which was the principle cause of the population's decline. Apparent increases in nester abundance for the North Atlantic DPS in recent years are encouraging but must be viewed cautiously, as the datasets represent a fraction of a green turtle generation, up to 50 years. While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue, the North Atlantic DPS appears to be somewhat resilient to future perturbations.

7.2.7.5 Critical Habitat

On September 2, 1998, NMFS designated critical habitat for green turtles, which is within the action area and include coastal waters surrounding Culebra Island, Puerto Rico (Figure 27). Seagrass beds surrounding Culebra provide important foraging resources for juvenile, sub-adult, and adult green turtles. Additionally, coral reefs surrounding the island provide resting shelter and protection from predators. This area provides important developmental habitat for the species. Activities that may affect the critical habitat include beach renourishment, dredge and fill activities, coastal construction, and freshwater discharge. Due to its location, this critical habitat would be accessible by individuals of the North Atlantic DPS.

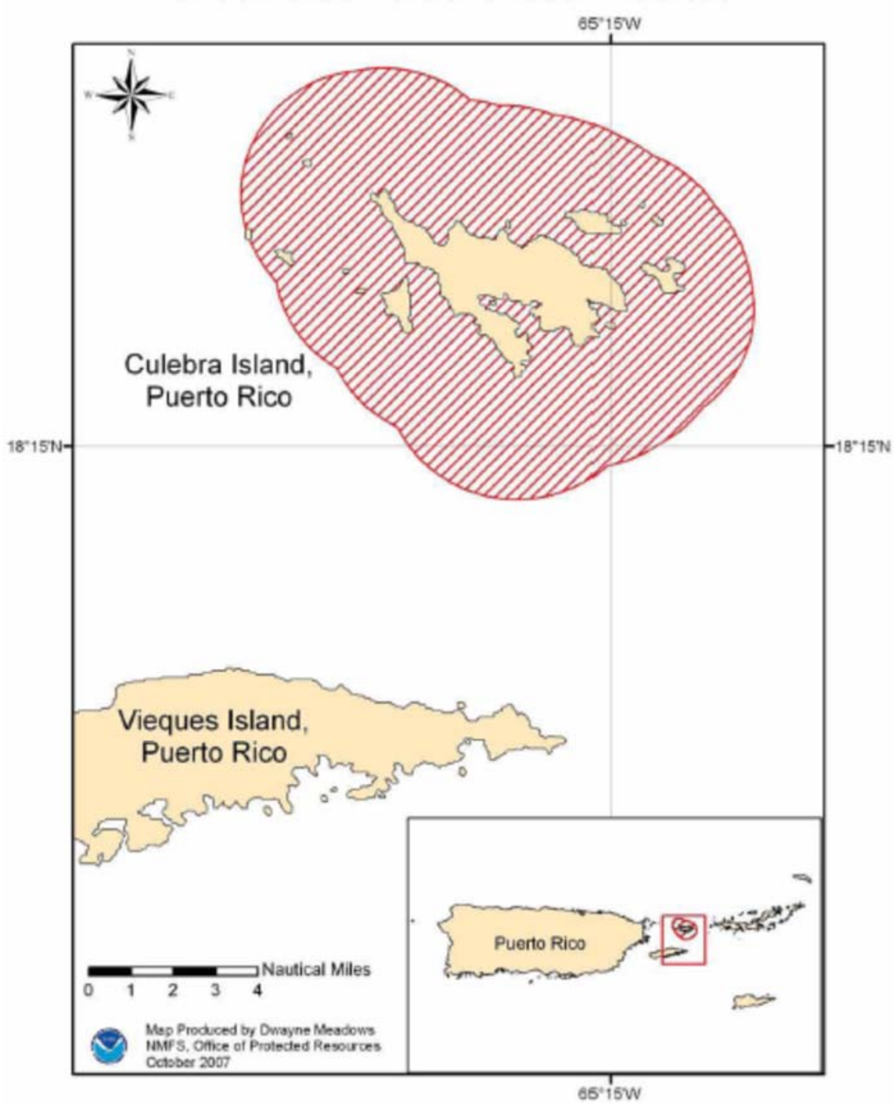


Figure 27: Map of green turtle designated critical habitat in Culebra Island, Puerto Rico.

7.2.7.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover green turtle populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 1998 and 1991 recovery plans for the Pacific, East Pacific, and Atlantic populations of green turtles for complete downlisting/delisting criteria for recovery goals for the species. Broadly, recovery plan goals emphasize the need to protect and manage nesting and marine habitat, protect and manage populations on nesting beaches and in the marine environment, increase public education, and promote international cooperation on sea turtle conservation topics.

7.2.8 Hawksbill Turtle

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, sub-tropical oceans (Figure 28).

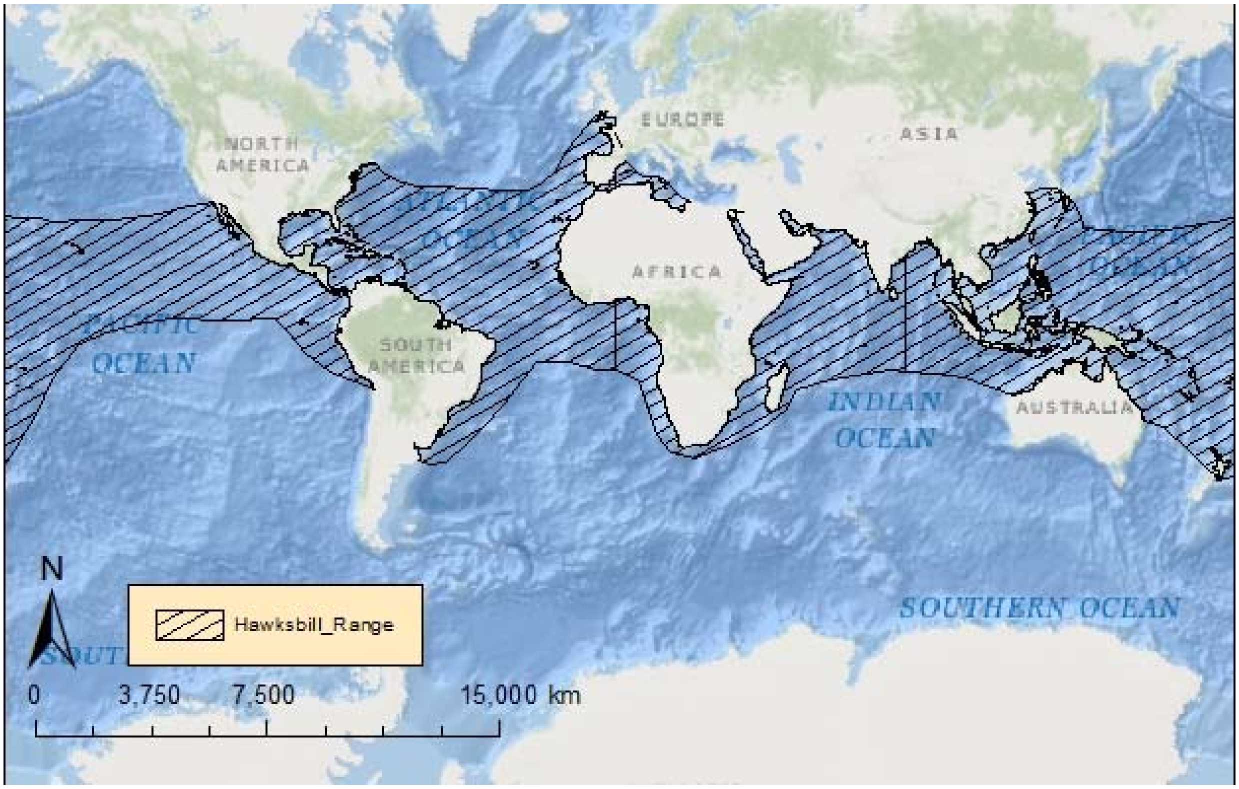


Figure 28. Map identifying the range of the endangered hawksbill turtle.

The hawksbill turtle has a sharp, curved, beak-like mouth and a "tortoiseshell" pattern on its carapace, with radiating streaks of brown, black, and amber. The species was first listed under the Endangered Species Conservation Act and listed as endangered under the ESA since 1973.

We used information available in the five year reviews (NMFS 2013; NMFS and USFWS 2007b) and the scientific literature to summarize the life history, population dynamics and status of the species, as follows.

7.2.8.1 Life History

Hawksbill turtles reach sexual maturity at twenty to forty years of age. Females return to their natal beaches every two to five years to nest and nest an average of three to five times per season. Clutch sizes are large (up to 250 eggs). Sex determination is temperature dependent, with warmer incubation producing more females. Hatchlings migrate to and remain in pelagic habitats until they reach approximately 22 to 25 cm in straight carapace length. As juveniles, they take up residency in coastal waters to forage and grow. As adults, hawksbill turtles use their sharp beak-like mouths to feed on sponges and corals. Hawksbill turtles are highly migratory and use a wide range of habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Satellite tagged sea turtles have shown significant variation in movement and migration patterns. Distance traveled between nesting and foraging ranges from a few hundred to a few thousand kilometers (Horrocks et al. 2001; Miller et al. 1998).

7.2.8.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes: abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the hawksbill turtle.

Surveys at 88 nesting sites worldwide indicate that 22,004 to 29,035 females nest annually (NMFS 2013). In general, hawksbill turtles are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean, where despite greater overall abundance, a greater proportion of the nesting sites are declining.

From 1980 through 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehaujes, and Playa Dos) increased 15 percent annually (Heppell et al. 2005); however, due to recent declines in nest counts, decreased survival at other life stages, and updated population modeling, this rate is not expected to continue (NMFS 2013).

Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. Genetic analysis of hawksbill turtles foraging off the Cape Verde Islands identified three closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the western Atlantic, where the vast majority of nesting has been documented (Mcclellan et al. 2010; Monzon-Arguello et al. 2010). Hawksbill turtles in the Caribbean Sea seem to have dispersed into separate populations (rookeries) after a bottleneck roughly 100,000 to 300,000 years ago (Leroux et al. 2012).

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, sub-tropical waters of the Atlantic, Indian, and Pacific Oceans. In their oceanic phase, juvenile hawksbill turtles can be found in *Sargassum* mats; post-oceanic hawksbill turtles may occupy a range of habitats that include coral reefs or other hard-bottom habitats, sea grass, algal beds, mangrove bays and creeks (Bjorndal and Bolten 2010; Musick and Limpus 1997).

7.2.8.3 Vocalization and Hearing

Currently, no information exists regarding hawksbill sea turtle vocalizations. Sea turtles primarily detect low frequencies with typical hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Bartol and Ketten 2006b; Bartol et al. 1999b; Lenhardt 1994; Lenhardt 2002; Ridgway et al. 1969b). Piniak et al. (2012) found hawksbill turtle hatchlings capable of hearing underwater sounds at frequencies of between 50 Hz to 1.6 kHz (maximum sensitivity at 200 to 400 Hz).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

7.2.8.4 Status

Long-term data on hawksbill turtle indicate that 63 sites have declined over the past 20 to 100 hundred years (historic trends are unknown for the remaining 25 sites). Recently 28 sites (68 percent) have experienced nesting declines, ten have experienced increases, three have remained stable, and 47 have unknown trends. The greatest threats to hawksbill turtles are overharvesting of sea turtles and eggs, degradation of nesting habitat, and fisheries interactions. Adult hawksbill turtles are harvested for their meat and carapace, which is sold as tortoiseshell. Eggs are taken at high levels, especially in Southeast Asia where collection approaches 100 percent in some areas. In addition, lights on or adjacent to nesting beaches are often fatal to emerging hatchlings and alters the behavior of nesting adults. The species' resilience to additional perturbation is low.

7.2.8.5 Critical Habitat

On September 2, 1998, NMFS established critical habitat for hawksbill turtles, which is within the action area, around Mona and Monito Islands, Puerto Rico (Figure 29). Aspects of these areas that are important for hawksbill turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for hawksbill turtle prey.

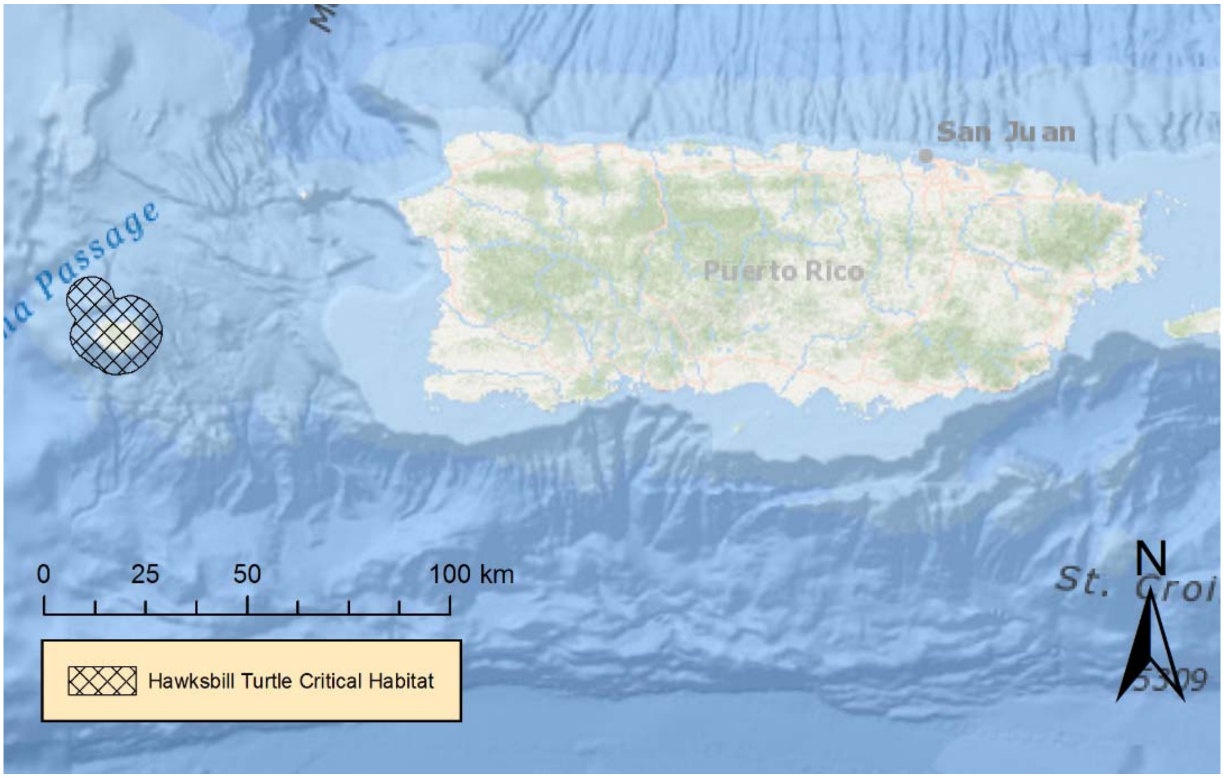


Figure 29. Map depicting hawksbill turtle designated critical habitat.

7.2.8.6 Recovery Goals

See the 1992 and 1998 Recovery Plans for the U.S. Caribbean, Atlantic, and Gulf of Mexico and U.S. Pacific populations of hawksbill turtles, respectively, for complete downlisting/delisting criteria for each of their respective recovery goals. The following items were the top recovery actions identified to support in the Recovery Plans:

- Identify important nesting beaches.
- Ensure long-term protection and management of important nesting beaches.
- Protect and manage nesting habitat; prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties, and breakwaters.
- Identify important marine habitats; protect and manage populations in marine habitat.
- Protect and manage marine habitat; prevent the degradation or destruction of important (marine) habitats caused by upland and coastal erosion.
- Prevent the degradation of reef habitat caused by sewage and other pollutants.
- Monitor nesting activity on important nesting beaches with standardized index surveys.
- Evaluate nest success and implement appropriate nest-protection on important nesting beaches.
- Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles and increase law-enforcement efforts to reduce illegal exploitation.
- Determine nesting beach origins for juveniles and sub-adult populations.

7.2.9 Kemp's Ridley Turtle

The Kemp's ridley turtle is considered to be the most endangered sea turtle, internationally (Groombridge 1982; Zwinenberg 1977). Its range extends from the Gulf of Mexico the Atlantic coast, with nesting beaches limited to a few sites in Mexico and Texas (Figure 30).

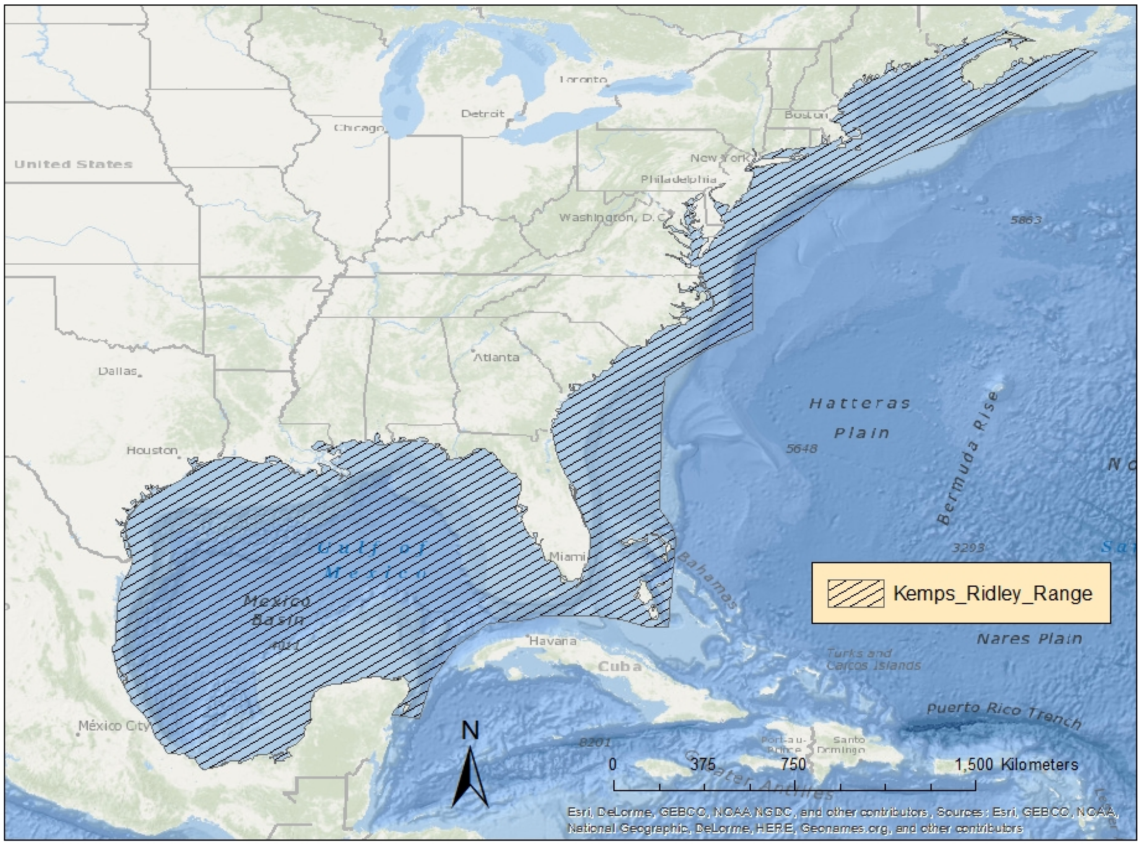


Figure 30. Map identifying the range of the endangered Kemp's ridley turtle.

Kemp's ridley turtles are the smallest of all sea turtle species, with a nearly circular top shell and pale yellowish bottom shell. The species was first listed under the Endangered Species Conservation Act and listed as endangered under the ESA since 1973 and listed as endangered under the ESA since 1973.

We used information available in the revised recovery plan (NMFS et al. 2011), the five-year review (NMFS and USFWS 2015), and the scientific literature to summarize the life history, population dynamics, and status of the species, as follows.

7.2.9.1 Life History

Females mature at 12 years of age. The average remigration is two years. Nesting occurs from April to July in large arribadas, primarily at Rancho Nuevo, Mexico. Females lay an average of 2.5 clutches per season. The annual average clutch size is 97 to 100 eggs per nest. The nesting location may be particularly important because hatchlings can more easily migrate to foraging grounds in deeper oceanic waters, where they remain for approximately two years before returning to nearshore coastal habitats. Juvenile Kemp's ridley turtles use these nearshore coastal habitats from April through November, but move towards more suitable overwintering habitat in deeper offshore waters (or more southern waters along the Atlantic coast) as water temperature drops. Adult habitat largely consists of sandy and muddy areas in shallow, nearshore waters less than 37 m deep, although they can also be found in deeper offshore waters. As adults, Kemp's ridley turtles forage on swimming crabs, fish, jellyfish, mollusks, and tunicates (NMFS et al. 2011).

7.2.9.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distributions as it relates to the Kemp's ridley turtle.

Of the sea turtle species in the world, the Kemp's ridley has declined to the lowest population level. Nesting aggregations at a single location (Rancho Nuevo, Mexico) were estimated at 40,000 females in 1947. By the mid-1980s, the population had declined to an estimated 300 nesting females. In 2014, there were an estimated 10,987 nests and 519,000 hatchlings released from three primary nesting beaches in Mexico (NMFS and USFWS 2015). The number of nests in Padre Island, Texas has increased over the past two decades, with one nest observed in 1985, four in 1995, 50 in 2005, 197 in 2014 (NMFS and USFWS 2015).

From 1980 through 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased 15 percent annually (Heppell et al. 2005); however, due to recent declines in nest counts, decreased survival of immature and adult sea turtles, and updated population modeling, this rate is not expected to continue (NMFS and USFWS 2015).

Genetic variability in Kemp's ridley turtles is considered to be high, as measured by heterozygosis at microsatellite loci (NMFS et al. 2011). Additional analysis of the mitochondrial DNA taken from samples of Kemp's ridley turtles at Padre Island, Texas showed six distinct haplotypes, with one of these also being found at Rancho Nuevo (Dutton et al. 2006).

The Kemp's ridley turtle occurs from the Gulf of Mexico and along the Atlantic coast of the U.S. (TEWG 2000). Kemp's ridley turtles have occasionally been found in the Mediterranean Sea, which may be due to migration expansion or increased hatchling production (Tomas and Raga 2008). The vast majority of individuals stem from breeding beaches at Rancho Nuevo on the Gulf of Mexico coast of Mexico. During spring and summer, juvenile Kemp's ridley turtles occur in the shallow coastal waters along the Atlantic continental shelf from New England to Florida, and from the northern Gulf of Mexico from Texas to north Florida. In the fall, most Kemp's ridley turtles migrate to deeper or more southern, warmer waters and remain there through the winter (Schmid 1998). As adults, many sea turtles remain in the Gulf of Mexico, with only occasional occurrence in the Atlantic Ocean (NMFS et al. 2011).

7.2.9.3 Vocalization and Hearing

Very little is known about sea turtle vocalizations. While leatherback sea turtles have been recorded making some sounds, there is no available data regarding Kemp's ridley sea turtle vocalizations. Sea turtles are low frequency hearing specialists, typically hearing frequencies 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Bartol and Ketten 2006b; Bartol et al. 1999b; Lenhardt 1994; Lenhardt 2002; Ridgway et al. 1969b). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Juvenile Kemp's ridley turtles can hear from 100 to 500 Hz, with a maximum sensitivity between 100 to 200 Hz at thresholds of 110 dB re: 1 μPa (Bartol and Ketten 2006b).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

7.2.9.4 Status

The Kemp's ridley turtle was listed as endangered in response to a severe population decline, primarily the result of egg collection. In 1973, legal ordinances prohibited the harvest of sea turtles from May to August, and in 1990, the harvest of all sea turtles was prohibited by presidential decree. In 2002, Rancho Nuevo was declared a sanctuary. A successful head-start program has resulted in re-establishment of nesting at Texan beaches. While fisheries bycatch remains a threat, the use of sea turtle excluder devices mitigates take. Fishery interactions and strandings, possibly due to forced submergence, appear to be the main threats to the species. It is clear that the species is steadily increasing; however, the species' limited range and low global abundance make it vulnerable to new sources of mortality as well as demographic and environmental randomness, all of which are often difficult to predict with any certainty. Therefore, its resilience to future perturbation is low.

7.2.9.5 Critical Habitat

No critical habitat has been designated for Kemp's ridley turtles.

7.2.9.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover Kemp's ridley turtle populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 2011 Final Bi-National (U.S. and Mexico) Revised Recovery Plan for Kemp's ridley turtles for complete downlisting/delisting criteria for each of their respective recovery goals. The following items were identified as priorities to recover Kemp's ridley turtles:

- Protect and manage nesting and marine habitats.
- Protect and manage populations on the nesting beaches and in the marine environment.
- Maintain a stranding network.
- Manage captive stocks.
- Sustain education and partnership programs.

- Maintain, promote awareness of and expand U.S. and Mexican laws.
- Implement international agreements.
- Enforce laws.

7.2.10 Leatherback Sea Turtle

The leatherback turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. It ranges from tropical to sub-polar latitudes, worldwide (Figure 31).

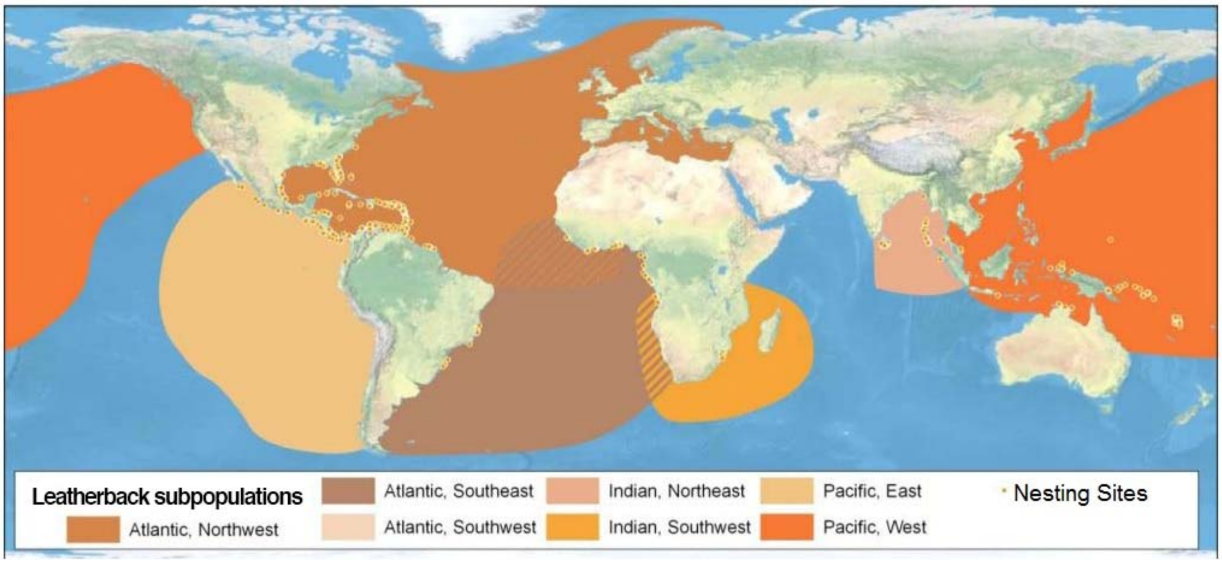


Figure 31. Map identifying the range of endangered leatherback turtle [adapted from Wallace et al. (2013)].

Leatherback turtles are the largest living sea turtle, reaching lengths of 1.8 m long, and weighing up to 907.2 kilograms. Leatherback turtles have a distinct black leathery skin covering their carapace with pinkish white skin on their belly. The species was first listed under the Endangered Species Conservation Act and listed as endangered under the ESA since 1973.

We used information available in the five year review (NMFS and USFWS 2013), critical habitat designation, and the scientific literature to summarize the life history, population dynamics, and status of the species as follows.

7.2.10.1 Life History

Age at maturity has been difficult to ascertain, with estimates ranging from five to 29 years (Avens et al. 2009; Spotila et al. 1996). Females lay up to seven clutches per season, with more than 65 eggs per clutch and eggs weighing greater than 80 grams (Reina et al. 2002; Wallace et al. 2007). The number of leatherback turtle hatchings that make it out of the nest on the beach (i.e., emergent success) is approximately 50 percent worldwide (Eckert et al. 2012). Females nest every one to seven years. Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherback turtles must consume large quantities to support their body weight. Leatherback turtles weigh about 33 percent more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (Aguirre et al. 2006; James et al. 2005). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price et al. 2004).

7.2.10.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the leatherback turtle.

Leatherback turtles are globally distributed, with nesting beaches in the Pacific, Indian, and Atlantic Oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Based on estimates calculated from nest count data, there are between 34,000 and 94,000 adult leatherback turtles in the North Atlantic Ocean (TEWG 2007). In contrast, leatherback turtle populations in the Pacific Ocean are much lower. Overall, Pacific populations have declines from an estimated 81,000 individuals to less than 3,000 total adults and sub-adults (Spotila et al. 2000). Population abundance in the Indian Ocean is difficult to assess due to lack of data and inconsistent reporting. Available data from southern Mozambique show that approximately 10 females nest per year from 1994 through 2004, and about 296 nests per year counted in South Africa (NMFS and USFWS 2013).

Population growth rates for leatherback turtles vary by ocean basin. Counts of leatherback turtles at nesting beaches in the western Pacific indicate that the sub-population has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013). Leatherback turtle sub-populations in the Atlantic Ocean, however, are showing signs of improvement. Nesting females in South Africa are increasing at an annual rate of four to 5.6 percent, and from nine to 13 percent in Florida and the U.S. Virgin Islands (TEWG 2007), believed to be a result of conservation efforts.

Analyses of mitochondrial DNA from leatherback turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton et al. 1999). Further analysis of samples taken from individuals from rookeries in the Atlantic and Indian Oceans suggest that each of the rookeries represent demographically independent populations (NMFS and USFWS 2013).

Leatherback turtles are distributed in oceans throughout the world (Figure 31). Leatherback turtles occur through marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011).

7.2.10.3 Vocalization and Hearing

Little is known about sea turtle sound use and production. Nesting leatherback turtles have been recorded producing sounds (sighs, grunts or belch-like sounds) up to 1,200 Hz with maximum energy from 300 to 500 Hz (Cook and Forrest 2005; Mrosovsky 1972). Although these sounds are thought to be associated with breathing (Cook and Forrest 2005; Mrosovsky 1972). In addition, leatherback embryos in eggs and hatchlings have been recorded making low-frequency pulsed and harmonic sounds (Ferrara et al. 2014).

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol and Ketten 2006b; Bartol et al. 1999b; Lenhardt 1994; Lenhardt 2002; Ridgway et al. 1969b). Piniak (2012) measured hearing of hatchlings leatherback turtles in water and in air, and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 Hz and 1.6 kHz in air and between 50 Hz and 1.2 kHz in water (lowest sensitivity recorded was 93 dB re: 1 μPa at 300 Hz).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 to 4 kHz (Patterson 1966).

7.2.10.4 Status

The leatherback turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The primary threats to leatherback turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, and sand extraction. Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea. Plastic ingestion is common in leatherbacks and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise). The species' resilience to additional perturbation is low.

7.2.10.5 Critical Habitat

On March 23, 1979, leatherback critical habitat was designated adjacent to Sandy Point, St. Croix, Virgin Islands from the 183 m (600 ft) isobath to mean high tide level between 17° 42' 12" North and 65° 50' 00" West (Figure 32). This habitat is occurs within the action area and is essential for nesting, which has been increasingly threatened since 1979, when tourism increased significantly, bringing nesting habitat and people into close and frequent proximity. The designated critical habitat is within the Sandy Point National Wildlife Refuge. Leatherback turtle nesting increased at an annual rate of thirteen percent from 1994 to 2001; this rate has slowed according to nesting data from 2001 to 2010 (NMFS and USFWS 2013).

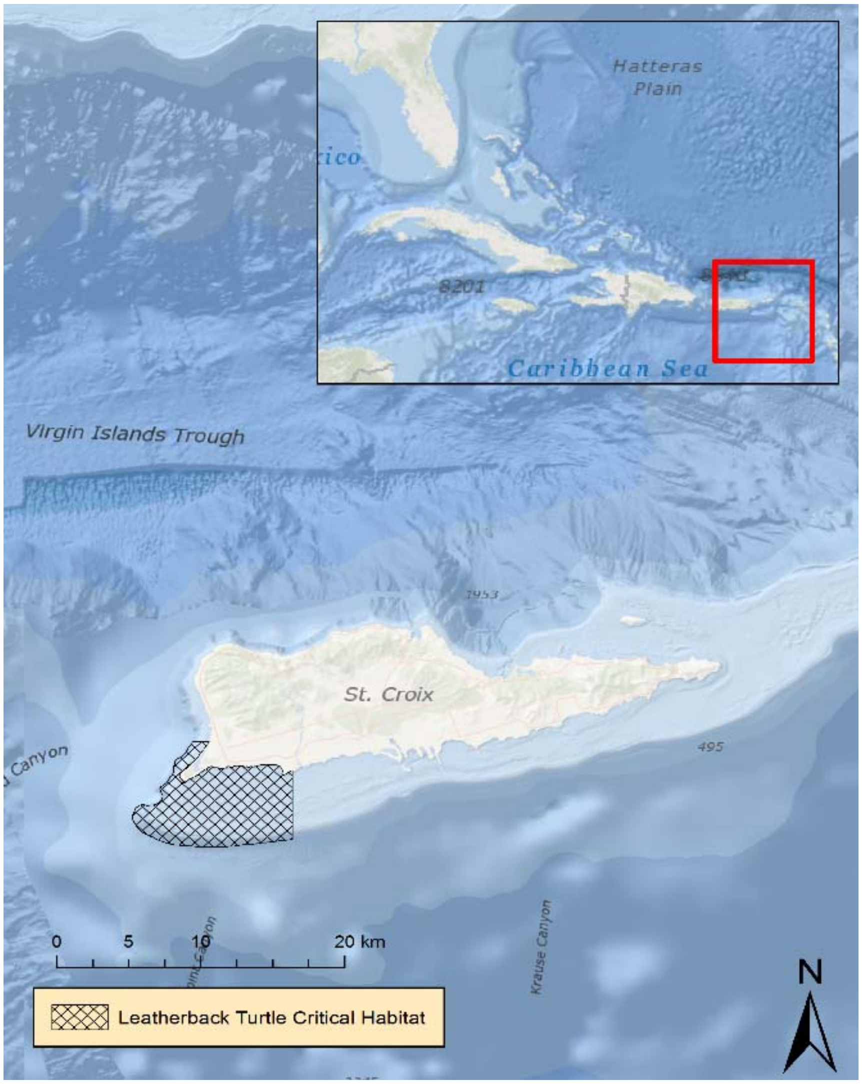


Figure 32. Map depicting leatherback turtle designated critical habitat in the United States Virgin Islands.

On January 20, 2012, NMFS issued a final rule to designate additional critical habitat for the leatherback turtle along the west coast of the United States. This additional critical habitat area is outside the action area. Accordingly, this habitat will not be considered further in this opinion.

7.2.10.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover leatherback turtle populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 1998 and 1991 Recovery Plans for the U.S. Pacific and U.S. Caribbean, Gulf of Mexico, and Atlantic leatherback turtles for complete downlisting/delisting criteria for each of their respective recovery goals. The following items were the top five recovery actions identified to support in the Leatherback Five Year Action Plan:

- Reduce fisheries interactions.
- Improve nesting beach protection and increase reproductive output.
- International cooperation.
- Monitoring and research.
- Public engagement.

7.2.11 Loggerhead Sea Turtle – Northwest Atlantic Ocean DPS

Loggerhead turtles are circumglobal and are found in the temperate and tropical regions of the Pacific, Indian, and Atlantic Oceans. Northwest Atlantic Ocean DPS of loggerhead turtles are found along eastern North America, Central America, and northern South America (Figure 33).

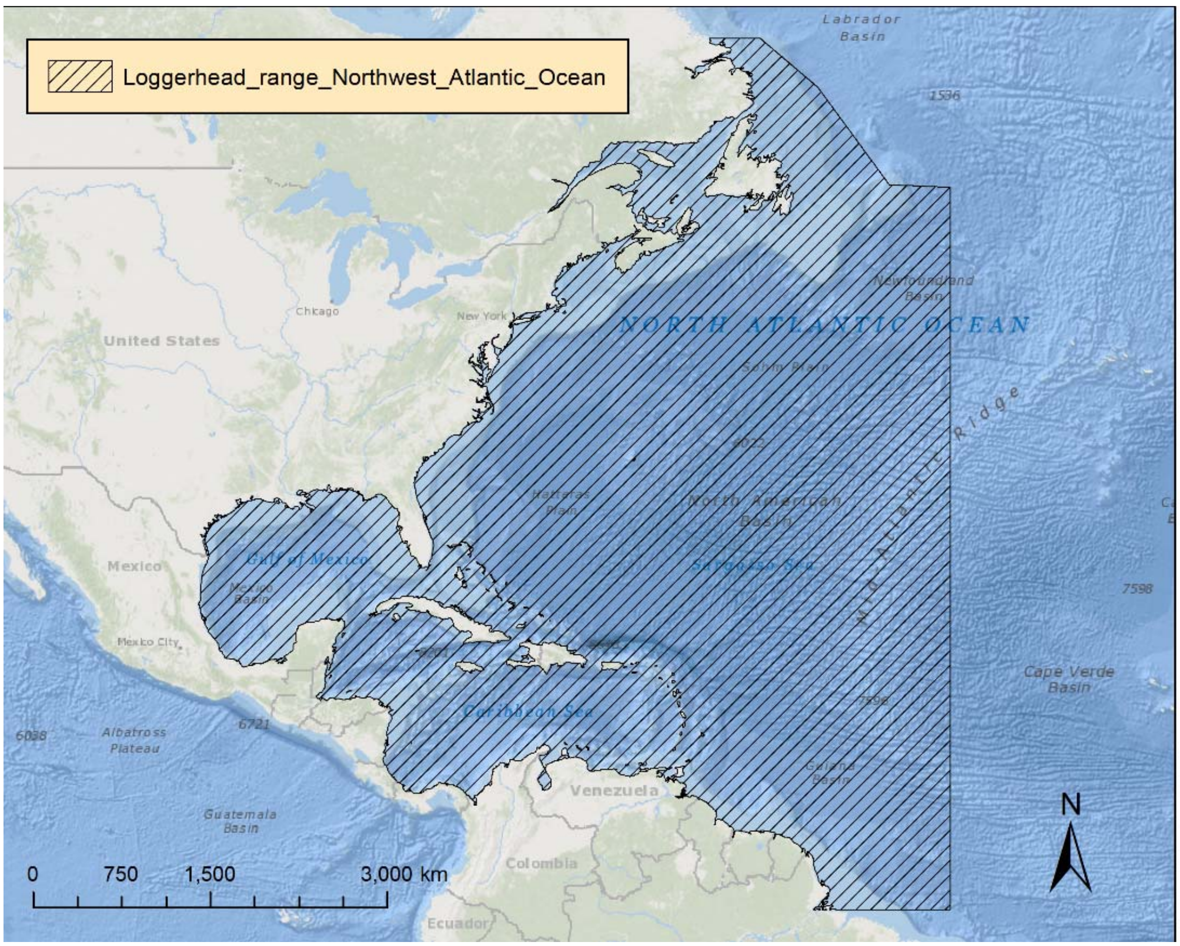


Figure 33. Map identifying the range of the Northwest Atlantic Ocean DPS of loggerhead turtles.

The loggerhead turtle is distinguished from other sea turtles by it reddish-brown carapace, large head, and powerful jaws. The species was first listed as threatened under the ESA in 1978 (43 FR 32800). On September 22, 2011, the NMFS designated nine DPSs of loggerhead turtles, with the Northwest Atlantic Ocean DPS of loggerhead turtle listed as threatened.

We used information available in the 2009 Status Review (Conant et al. 2009), the final ESA-listing rule, and the scientific literature to summarize the life history, population dynamics, and status of the species, as follows.

7.2.11.1 Life History

Mean age at first reproduction for female loggerhead turtles is 30 years. Females lay an average of three clutches per season. The annual average clutch size is 112 eggs per nest. The average remigration interval is 2.7 years. Nesting occurs on beaches, where warm, humid sand temperatures incubate the eggs. Temperature determines the sex of the sea turtle during the middle of the incubation period. Loggerhead sea turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in the neritic zone (i.e., coastal waters). Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerhead turtles. Neritic juvenile loggerheads forage on crabs, mollusks, jellyfish and vegetation, where as adults typically prey on benthic invertebrates such as mollusks and decapods.

7.2.11.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Northwest Atlantic Ocean DPS of loggerhead turtle.

There is a general agreement that the number of nesting females provides a useful index of the species' population size and stability at this life stage, even though there are no doubts about the ability to estimate the overall population size. Adult nesting females often account for less than one percent of total population numbers (Bjorndal et al. 2005). The global abundance of nesting female loggerhead turtles is estimated at 43,320 to 44,560. Using a stage/age demographic model, the adult female population size of the DPS is estimated at 20,000 to 40,000 females, and 53,000 to 92,000 nests annually (NMFS 2009a). In 2010, there were estimated to be approximately 801,000 loggerhead turtles (greater than 30 cm in size, inter-quartile range of approximately 521,000–1,111,000) in northwestern Atlantic continental shelf region based on aerial surveys (NMFS 2011f).

Based on genetic information, the Northwest Atlantic Ocean DPS of loggerhead turtle is further categorized into five recovery units corresponding to nesting beaches. These are Northern Recovery Unit, Peninsular Florida Recovery Unit, Dry Tortugas Recovery Unit, Northern Gulf of Mexico Recovery Unit, and the Greater Caribbean Recovery Unit. The Northern Recovery Unit, from North Carolina to northeastern Florida, and is the second largest nesting aggregation in the Northwest Atlantic Ocean DPS, with an average of 5,215 nests from 1989 through 2008, and approximately 1,272 nesting females (NMFS and USFWS 2008). The Peninsular Florida Recovery Unit hosts more than 10,000 females nesting annually, which constitutes 87 percent of all nesting effort in the Northwest Atlantic Ocean DPS of loggerhead turtles (Ehrhart et al. 2003). The Dry Tortugas Recovery Unit includes all islands west of Key West, Florida. The only available data for the nesting sub-population on Key West comes from a census conducted from 1995 through 2004 (excluding 2002), which provided a mean of 246 nests per year, or about 60 nesting females (NMFS and USFWS 2007c). The Northern Gulf of Mexico Recovery Unit has between 100 to 999 nesting females annually, and a mean of 910 nests per year. The Greater Caribbean Recovery Unit encompasses nesting sub-populations in Mexico to French Guiana, the Bahamas, and the Lesser and Greater Antilles. The majority of nesting for this recovery unit occurs on the Yucatán peninsula, in Quintana Roo, Mexico, with 903 to 2,331 nests annually (Zurita et al. 2003). Other significant nesting sites are found throughout the Caribbean Sea, and including Cuba, with approximately 250 to 300 nests annually (Ehrhart et al. 2003), and over 100 nests annually in Cay Sal in the Bahamas (NMFS and USFWS 2008).

Four of the Northwest Atlantic DPS recovery units have adequate data to examine population trends, the Northern Recovery Unit, the Peninsular Florida Recovery Unit, the Northern Gulf of Mexico Recovery Unit, and the Greater Caribbean Recovery Unit, and all appear to be declining (Conant et al. 2009). Nest counts taken at index beaches in Peninsular Florida show a significant decline in loggerhead sea turtle nesting from 1989 through 2006, most likely attributed to mortality of oceanic-stage loggerhead turtles caused by fisheries bycatch (Witherington et al. 2009). Loggerhead turtle nesting on the Archie Carr National Wildlife Refuge (representing individuals of the Peninsular Florida sub-population) has fluctuated over the past few decades. There was an average of 9,300 nests throughout the 1980s, with the number of nests increasing into the 1990s until it reached an all-time high in 1998, with 17,629 nests. From that point, the number of loggerhead turtle nests at the Archie Carr National Wildlife Refuge have declined steeply to a low of 6,405 in 2007, increasing again to 15,539, still a lower number of nests than in 1998 (Bagley et al. 2013). For the Northern Recovery Unit, nest counts at loggerhead turtles nesting beaches in North Carolina, South Carolina, and Georgia declined at 1.9 percent annually from 1983 through 2005 (NMFS and USFWS 2007c). The nesting sub-population in the Florida panhandle has exhibited a significant declining trend from 1995 through 2005 (Conant et al. 2009; NMFS and USFWS 2007c). Population model estimates predict an overall population decline of 17 percent for the St. Joseph Peninsula, Florida sub-population of the Northern Gulf of Mexico recovery unit (Lamont et al. 2014). However, more recent information about sea turtle nest counts in Florida indicate from 2007-2015 there has been an increase based upon the 26 core index beaches within 2015 (52,647) nests compared to 2013 and 2014; but this was lower than nest count data from 2012 (Florida Fish and Wildlife Conservation Commission 2015).

However, as mentioned previously, genetic analyses were the bases for establishing the five recovery units (Conant et al. 2009). A more recent analysis using expanded mitochondrial DNA sequences revealed that rookeries from the Gulf and Atlantic coasts of Florida are genetically distinct, and that rookeries from Mexico's Caribbean Sea coast express high haplotype diversity (Shamblin et al. 2014). Furthermore, the results suggest that the Northwest Atlantic Ocean DPS should be considered as 10 management units: (1) South Carolina and Georgia, (2) central eastern Florida, (3) southeastern Florida, (4) Cay Sal, Bahamas, (5) Dry Tortugas, Florida, (6) southwestern Cuba, (7) Quintana Roo, Mexico, (8) southwestern Florida, (9) central western Florida, and (10) northwestern Florida (Shamblin et al. 2012).

Loggerhead turtles are circumglobal, occurring throughout the temperate and tropical regions of the Pacific, Indian, and Atlantic Oceans, returning to their natal region for mating and nesting. Adults and sub-adults occupy nearshore habitat. While in their oceanic phase, loggerhead turtles undergo long migrations using ocean currents. Individuals from multiple nesting colonies can be found on a single feeding ground. Loggerhead turtle hatchlings from the western Atlantic Ocean disperse widely, most likely using the Gulf Stream to drift throughout the Atlantic Ocean. Mitochondrial DNA evidence demonstrates that juvenile loggerhead turtles from southern Florida nesting beaches comprise the vast majority (71 to 88 percent) of individuals found in foraging grounds throughout the western and eastern Atlantic Ocean: Nicaragua, Panama, Azores and Madeira, Canary Islands and Adalusia, Gulf of Mexico, and Brazil (Masuda 2010).

7.2.11.3 Vocalization and Hearing

Little is known about sea turtle sound use and production, they are not know to vocalize underwater. Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol and Ketten 2006b; Bartol et al. 1999b; Lenhardt 1994; Lenhardt 2002; Ridgway et al. 1969b). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Bartol et al. (1999b) reported effective hearing range for juvenile loggerhead turtles is from at least 250 to 750 Hz. Both yearling and two-year old loggerhead turtles had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re: 1 μPa and two-year olds: about 86 dB re: 1 μPa), with threshold increasing rapidly above and below that frequency (Bartol and Ketten 2006b). Underwater tones elicited behavioral responses to frequencies between 50 and 800 Hz and auditory evoked potential responses between 100 and 1,131 Hz in one adult loggerhead turtle (Martin et al. 2012b). The lowest threshold recorded in this study was 98 dB re: 1 μPa at 100 Hz. Lavender et al. (2014) found post-hatchling loggerhead turtles responded to sounds in the range of 50 to 800 Hz while juveniles responded to sounds in the range of 50 Hz to 1 kHz. Post-hatchlings had the greatest sensitivity to sounds at 200 Hz while juveniles had the greatest sensitivity at 800 Hz (Lavender et al. 2014).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 ha and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responds beyond 3 or 4 kHz (Patterson 1966).

7.2.11.4 Status

Due to declines in nest counts at index beaches in the U.S. and Mexico, and continued mortality of juveniles and adults from fishery bycatch, the Northwest Atlantic Ocean DPS of loggerhead turtle is at risk and likely to decline in the foreseeable future (Conant et al. 2009).

7.2.11.5 Critical Habitat

On July 10, 2014, NMFS and the U.S. Fish and Wildlife Service designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead turtles within the action area, along the U.S.

Atlantic and Gulf of Mexico coasts from North Carolina to Mississippi (79 FR 39856) (Figure 34). These areas contain one or a combination of nearshore reproductive habitat, winter area, breeding areas, and migratory corridors. The critical habitat is categorized into 38 occupied marine areas and 1,102.4 km (685 miles) of nesting beaches. The PBFs identified for the different habitat types include waters adjacent to high density nesting beaches, waters with minimal obstructions and manmade structures, high densities of reproductive males and females, appropriate passage conditions for migration, conditions that support *Sargassum* habitat, available prey, and sufficient water depth and proximity to currents to ensure offshore transport of post-hatchlings.

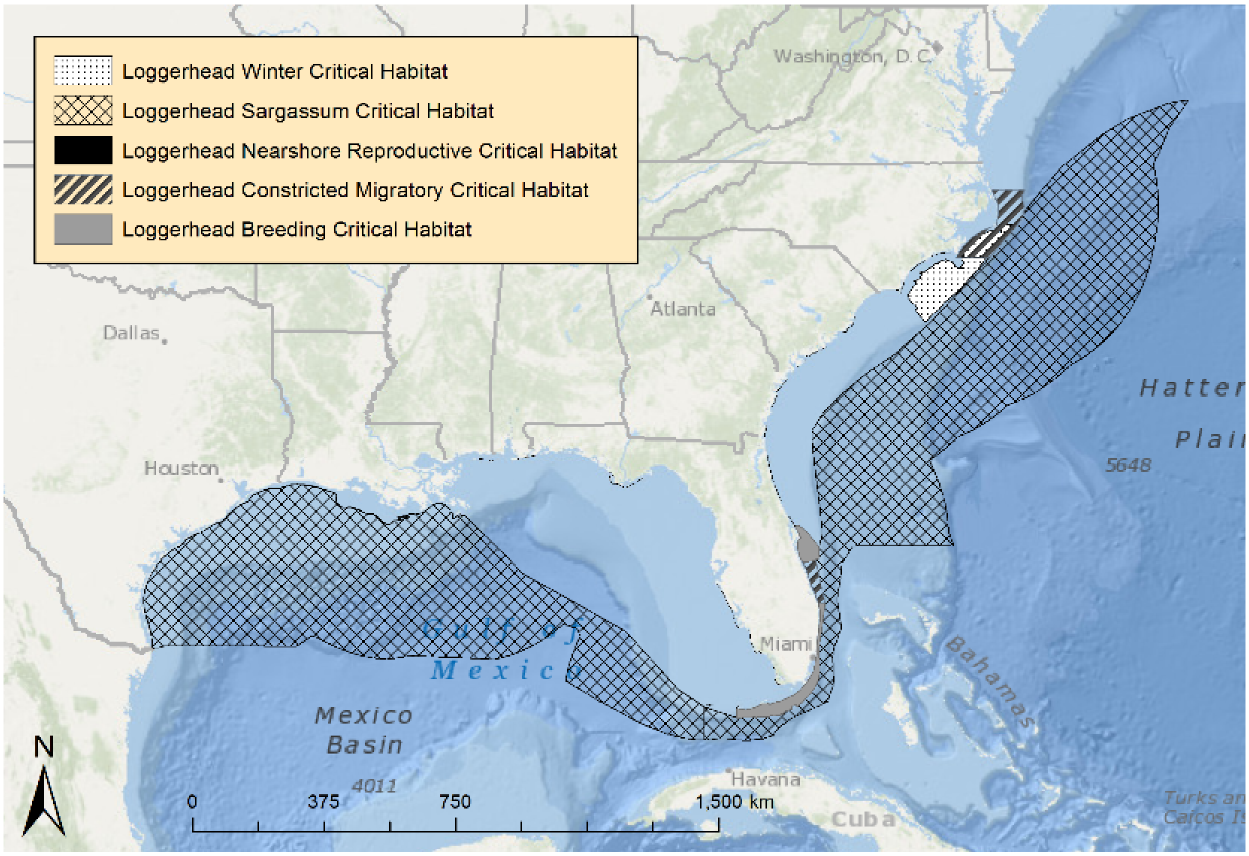


Figure 34. Map identifying designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead turtle.

7.2.11.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover loggerhead turtle populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 2009 Final Recovery Plan for the Northwest Atlantic Population of Loggerheads for complete downlisting/delisting criteria for each of the following recovery objectives:

- Ensure that the number of nests in each recovery unit is increasing and that this increase corresponds to an increase in the number of nesting females.

- Ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing and is increasing at a greater rate than strandings of similar age classes.
- Manage sufficient nesting beach habitat to ensure successfully nesting.
- Manage sufficient feeding, migratory, and interesting marine habitats to ensure successful growth and reproduction.
- Eliminate legal harvest.
- Implement scientifically based nest management plans.
- Minimize nest predation.
- Recognize and respond to mass/unusual mortality or disease event appropriately.
- Develop and implement local, state, Federal, and international legislation to ensure long-term protection of loggerhead turtles and their terrestrial and marine habitats.
- Minimize bycatch in domestic and international commercial and artisanal fisheries.
- Minimize trophic changes from fishery harvest and habitat alteration.
- Minimize marine debris ingestions and entanglement.
- Minimize vessel strike mortality.

7.2.12 Atlantic Salmon – Gulf of Maine DPS

The Atlantic salmon is an anadromous fish, occupying freshwater streams in North America. There are three Atlantic salmon DPSs in the United States: Long Island Sound, Central New England, and the Gulf of Maine DPSs (Fay et al. 2006a). The Gulf of Maine DPS Atlantic salmon are the only DPS listed under the ESA and are found in watersheds throughout Maine (Figure 35).

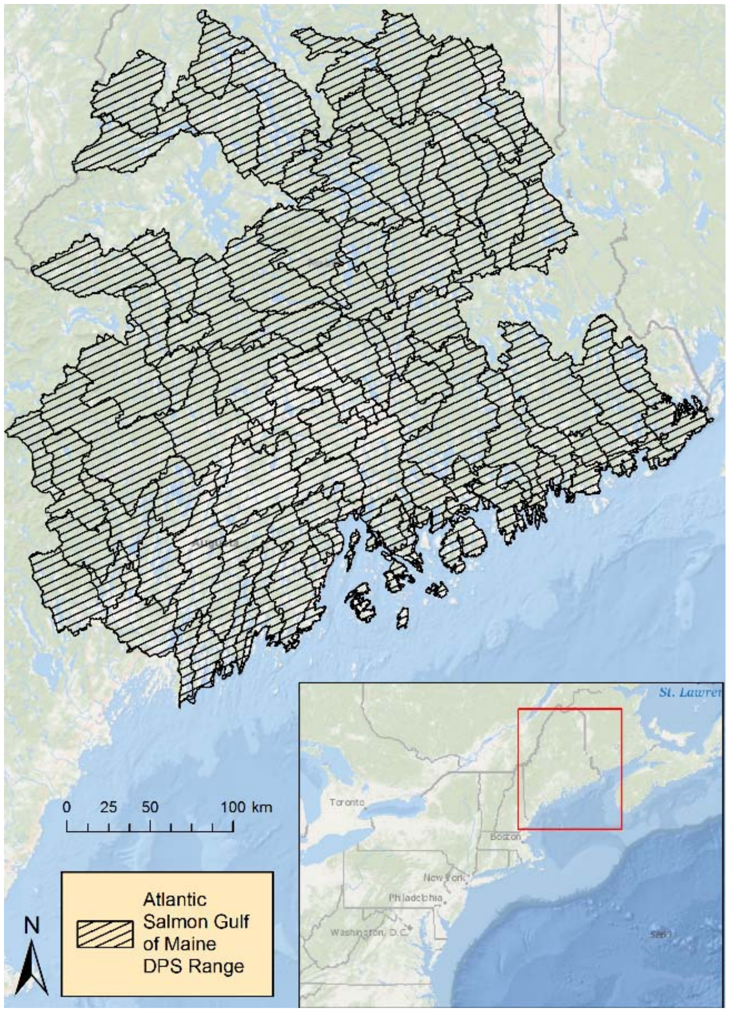


Figure 35. Map identifying the range of Gulf of Maine DPS of Atlantic salmon.

Adult Atlantic salmon are silver-blue with dark spots. They average 8-12 pounds but can get as large as 30 pounds. The Gulf of Maine DPS was first listed as endangered by the U. S. Fish and Wildlife Service and NMFS on November 17, 2000. The listing was refined by the Services on June 19, 2009, to include all anadromous Atlantic salmon whose freshwater range occurs in the watersheds from the Androscoggin River northward along the Maine coast to the Dennys River, and wherever these fish occur in the estuarine and marine environment.

We used information available in the 2006 status review (Fay et al. 2006a) and recent scientific publications to summarize the life history, population dynamics and status of the species, as follows.

7.2.12.1 Life History

Atlantic salmon have a complex life history that ranges from territorial rearing in rivers to extensive feeding migrations on the high seas. Most adult Atlantic salmon ascend the rivers of New England beginning in the spring, continuing into the fall with the peak occurring in June. Adult Atlantic salmon typically spawn around early November and eggs hatch in late March or April. Preferred spawning habitat is a gravel substrate with adequate water circulation to keep the buried eggs well oxygenated. Juveniles spend about two years feeding in freshwater until they weigh approximately two ounces and are six inches in length. Smoltification (the physiological and behavioral changes required for the transition to saltwater) usually occurs at age two for Gulf of Maine DPS Atlantic salmon. Gulf of Maine DPS Atlantic salmon migrate more than 4,000 km in the open ocean to reach feeding areas in the Davis Strait between Labrador and Greenland. The majority of Gulf of Maine DPS Atlantic salmon (about ninety percent) spend two winters at sea before reaching maturity and returning to their natal rivers, with the remainder spending one or three winters at sea. At maturity, Gulf of Maine DPS Atlantic salmon typically weigh between eight to fifteen pounds and average thirty inches in length. Atlantic salmon are iteroparous (i.e., capable of spawning more than once).

7.2.12.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Gulf of Maine DPS of Atlantic salmon.

Gulf of Maine DPS Atlantic salmon can be found in at least eight rivers in Maine: Dennys River, East Machias River, Machias River, Pleasant River, Narraguagus River, Ducktrap River, Sheepscot River, Cove Brook, Penobscot River, Androscoggin River and the Kennebec River. The Gulf of Maine DPS Atlantic salmon is genetically distinct from other Atlantic salmon populations in Canada, and can be further delineated into stocks: Downeast Coastal stock which includes the Dennys, East Machias, Machias, Pleasant and Narraguagus Rivers; Penobscot Bay stock; and the Merrymeeting Bay (Sheepscot) stock. The hatchery supplementation programs for the Penobscot and Merrymeeting Bays stocks use river-specific broodstock (USASAC 2016). The conservation hatchery program plays a significant role in the persistence of Gulf of Maine DPS Atlantic salmon. Adult returns of Gulf of Maine DPS Atlantic salmon captured in six Maine rivers from 1997 to 2004 ranged from 567 to 1,402. These counts include both wild and hatchery origin fish. Each year, the majority (92 to 98 percent) of adult returns were found in the Penobscot River; the Narraguagus River supported between 0.8 to 4.1 percent of adult returns during those years (Fay et al. 2006a). In 2015, four million juvenile salmon (eggs, fry, parr and smolts) and 4,271 adults were stocked in the Connecticut, Merrimack, Saco, Penobscot and five other coastal rivers in Maine (USASAC 2016). The total number of adult returns to U.S. rivers in 2015 was 921, the majority (80 percent) of which were of hatchery origin. The fact that so few of the returning adults are naturally-reared is concerning to managers; the reliance on hatcheries can pose risks such as artificial selection, inbreeding depression and outbreeding depression (Fay et al. 2006a). There is no population growth rate available for Gulf of Maine DPS Atlantic salmon. However, the consensus is that the DPS exhibits a continuing declining trend (NOAA 2016a).

7.2.12.3 Vocalization and Hearing

Data on sound production in species in the family Salmonidae is scarce, but they do appear to produce some sounds during spawning that may be used for intraspecific signally, including high and low frequency drumming sounds likely produced by the swimbladder (Neproshin and Kulikova 1975, and Neproshin 1972 as reviewed in Kuznetsov 2009). Salmonidae are all thought to have similar auditory systems and hearing sensitivities (Popper 1977; Popper et al. 2007; Wysocki et al. 2007a). Most of the data available are on the hearing capability of Atlantic salmon (*Salmo salar*), which is a “hearing generalist” with a relatively poor sensitivity to sound (Hawkins and Johnstone 1978). Based on the information available, we assume that the Gulf of Maine DPS of Atlantic salmon have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins and Johnstone 1978; Knudsen et al. 1992; Knudsen et al. 1994).

7.2.12.4 Status

Historically, Atlantic salmon occupied U.S. rivers throughout New England, with an estimated 300,000 to 500,000 adults returning annually (Fay et al. 2006a). Of the three DPSs found in the United States, native salmon in the Long Island Sound and Central New England DPSs were extirpated in the 1800s. Several rivers within these DPSs are presently stocked with Gulf of Maine DPS salmon. The Gulf of Maine DPS Atlantic salmon was listed as endangered in response to population decline caused by many factors, including overexploitation, degradation of water quality and damming of rivers, all of which remain persistent threats (Fay et al. 2006a). Coastal development poses a threat as well, as artificial light can disrupt and delay fry dispersal (Riley et al. 2013). Climate change may cause changes in prey availability and thermal niches, further threatening Atlantic salmon populations (Mills et al. 2013). Even with current conservation efforts, returns of adult Atlantic salmon to the Gulf of Maine DPS rivers remain extremely low, with an estimated extinction risk of nineteen to seventy-five percent in the next one hundred years (Fay et al. 2006a). Estimated Atlantic salmon returns to U.S. rivers from 2005 to 2015 range from a low in 2014 of 450 to a high in 2011 of 4,178 (USASAC 2016). Based on the information above, the species would likely have a low resilience to additional perturbations.

7.2.12.5 Critical Habitat

On June 19, 2009, NMFS and the U.S. Fish and Wildlife Service designated critical habitat for the Gulf of Maine DPS of Atlantic salmon (Figure 36). The critical habitat includes all anadromous Atlantic salmon streams whose freshwater range occurs in watersheds from the Androscoggin River northward along the Maine coast northeastward to the Dennys River, and wherever these fish occur in the estuarine and marine environment. Primary constituent elements were identified within freshwater and estuarine habitats of the occupied range of the Gulf of Maine DPS and include sites for spawning and incubation, juvenile rearing, and migration. The Rule also identified three salmon habitat recovery units to identify geographic and population-level factors to aid in managing the habitat: Merrymeeting Bay, Penobscot, and Downeast. Critical habitat and primary constituent elements were not designated within marine environments because of the limited knowledge of the physical and biological features that the species uses during the marine phase of its life.

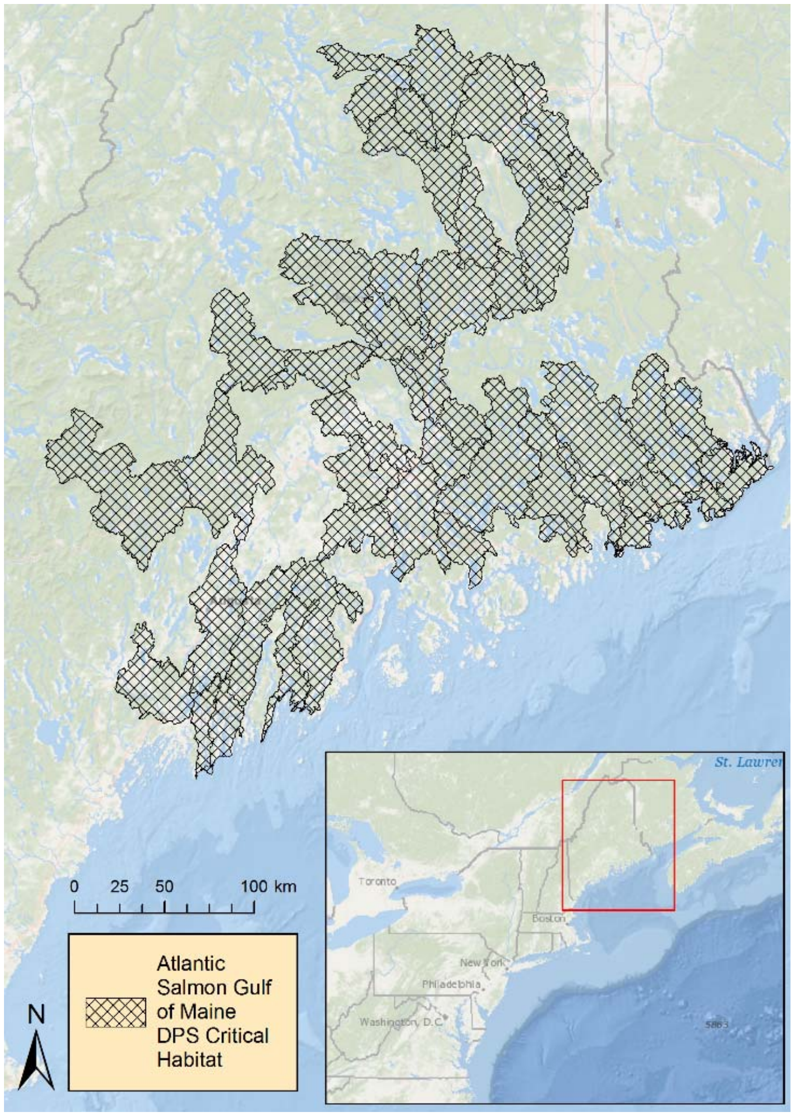


Figure 36: Map of designated critical habitat for the Atlantic salmon Gulf of Maine DPS.

7.2.12.6 Recovery Goals

See the 2016 Draft Recovery Plan for the Gulf of Maine DPS Atlantic Salmon (USFWS and NMFS 2016), for complete down listing/delisting criteria for each of their respective recovery goals. Recovery actions identified in the Draft Recovery Plan include the following:

- Enhance connectivity between ocean and freshwater habitats important for recovery
- Maintain the genetic diversity of Atlantic salmon populations over time

- Increase adult spawners through the conservation hatchery program
- Increase Atlantic salmon survival through increased ecosystem understanding and identification of spatial and temporal constraints to salmon marine productivity to inform and support management actions that improve survival
- Consult with all involved Tribes on a government-to-government basis
- Collaborate with partners and engage interested parties in recovery efforts

7.2.13 Atlantic Sturgeon

Atlantic sturgeon are anadromous, spawning in freshwater but spending most of their sub adult and adult life in the marine environment. Five DPSs of Atlantic sturgeon were listed under the ESA in 2012. The Gulf of Maine DPS is listed as threatened while the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs are listed as endangered (Figure 37).

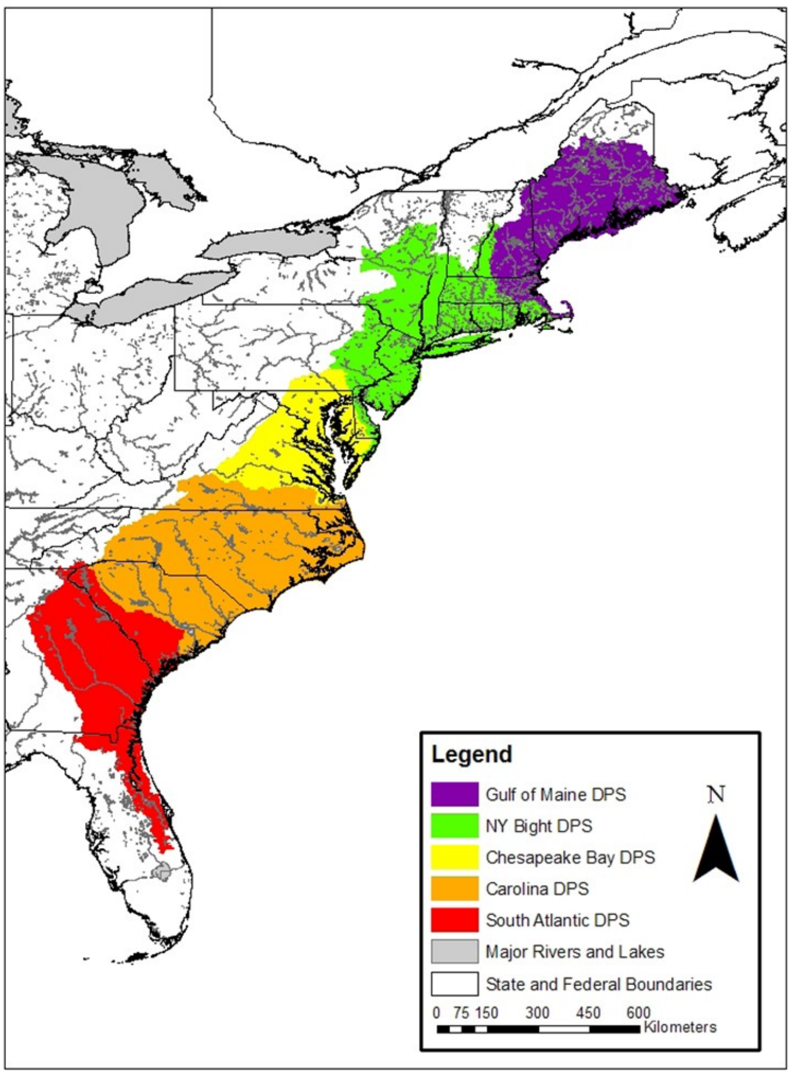


Figure 37. Range and boundaries of the five Atlantic sturgeon DPSs.

Sturgeon are among the most primitive of the bony fishes. They can grow to approximately 14 ft long and can weigh up to 800 pounds. Atlantic sturgeon are bluish-black or olive brown dorsally (on their back) with paler sides, a white belly, and have five major rows of dermal "scutes".

This section provides general information on the Atlantic sturgeon coast-wide population, including information about the species life history, population dynamics, and status. The subsections that follow provide information and characteristics particular to each of the five ESA-listed DPSs of Atlantic sturgeon.

7.2.13.1 Life History

The general life history pattern of Atlantic sturgeon is that of a long lived (approximately 60 years), late maturing, iteroparous, anadromous species (ASSRT 2007; Dadswell 2006). Atlantic sturgeon spawn in freshwater, but spend most of their sub adult and adult life in the marine environment.

Traditionally, it was believed that spawning within all populations occurred during the spring and early summer months. More recent studies, however, suggest that spawning occurs from late summer to early autumn in two tributaries of the Chesapeake Bay (James River and York River, Virginia) and in the Altamaha River, Georgia (Balazik et al. 2012c; Hager et al. 2014a).

Sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces (e.g., cobble) (Smith and Clugston 1997). Hatching occurs approximately 94 to 140 hours after egg deposition, and larvae assume a demersal existence (Smith et al. 1980). The yolk sac larval stage is completed in about eight to 12 days, during which time the larvae move downstream to rearing grounds over a six to 12-day period (Kynard and Horgan 2002). During the first half of their migration downstream, movement is limited to nighttime. During the day, larvae use benthic structure (e.g., gravel matrix) as refugia (Kynard and Horgan 2002). During the latter half of migration when larvae are more fully developed, movement to rearing grounds occurs both day and night. The larvae grow rapidly and are 4 to 5.5 inches long at a month old (MSPO 1993). At this size, the young sturgeon bear teeth and have sharp, closely spaced spine-tipped scutes. As growth continues, they lose their teeth, the scutes separate and lose their sharpness.

Juvenile Atlantic sturgeon continue to move downstream into brackish waters, and eventually become residents in estuarine waters. Juvenile Atlantic sturgeon are resident within their natal estuaries for two to six years, depending on their natal river of origin, after which they emigrate as sub adults to coastal waters (Dovel 1983) or to other estuaries seasonally (Waldman et al. 2013). Atlantic sturgeon undertake long marine migrations and utilize habitats up and down the East Coast for rearing, feeding, and migrating (Bain 1997; Dovel 1983; Stevenson 1997). Migratory sub adults and adults are normally located in shallow (10-50m) nearshore areas dominated by gravel and sand substrate (Stein et al. 2004b). Tagging and genetic data indicate that sub adult and adult Atlantic sturgeon may travel widely once they emigrate from rivers (Bartron 2007; Wirgin et al. 2015). Once in marine waters, sub adults undergo rapid growth (Dovel 1983; Stevenson 1997). Despite extensive mixing in coastal waters, Atlantic sturgeon display high site fidelity to their natal streams.

Atlantic sturgeon have been aged to 60 years (Mangin 1964), but this should be taken as an approximation because the age validation studies conducted to date show ages cannot be reliably estimated after 15-20 years (Stevenson and Secor 2000). Vital parameters of sturgeon populations generally show clinal variation with faster growth, earlier age at maturation, and shorter life span in more southern systems. Spawning intervals range from one to five years for male Atlantic sturgeon (Collins et al. 2000; Smith 1985) and three to five years for females (Schueller and Peterson 2010; Stevenson and Secor 2000). Fecundity of Atlantic sturgeon is correlated with age and body size, ranging from approximately 400,000 to eight million eggs (Dadswell 2006; Smith et al. 1982; Van Eenennaam and Doroshov 1998). The average age at which 50 percent of Atlantic sturgeon maximum lifetime egg production is achieved is estimated to be 29 years, approximately three to 10 times longer than for most other bony fish species (Boreman 1997).

Atlantic sturgeon feed on mollusks, polychaeta worms, gastropods, shrimps, pea crabs, decapods, amphipods, isopods, and small fishes in the marine environment (Collins et al. 2006; Guilbard et al. 2007; Savoy 2007). The sturgeon "roots" in the sand or mud with its snout, like a pig, to dislodge worms and mollusks that it sucks into its protrusible mouth, along with considerable amounts of mud. The Atlantic sturgeon has a stomach with very thick, muscular walls that resemble the gizzard of a bird. This gizzard enables it to grind such food items as mollusks and gastropods (MSPO 1993).

7.2.13.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Atlantic sturgeon.

The Atlantic sturgeon's historic range included major estuarine and riverine systems that spanned from Hamilton Inlet on the coast of Labrador, Canada, to the Saint Johns River in Florida (ASSRT 2007; Smith and Clugston 1997). Atlantic sturgeon have been documented as far south as Bermuda and Venezuela (Lee et al. 1980). Historically, Atlantic sturgeon were present in approximately 38 rivers in the United States from St. Croix, Maine, to the Saint Johns River, Florida, of which 35 rivers have been confirmed to have had historic spawning populations. Atlantic sturgeon are currently present in 36 rivers, and spawning occurs in at least 21 of these (ASSRT 2007). Other estuaries along the U.S. Atlantic Coast formed by rivers that do not support Atlantic sturgeon spawning populations may still be important as rearing habitats.

Atlantic sturgeon throughout their range exhibit ecological separation during spawning that has resulted in multiple, genetically distinct, interbreeding population segments. Studies have consistently found populations to be genetically diverse and indicate that there are between seven and ten populations that can be statistically differentiated (Grunwald et al. 2008; King et al. 2001; Waldman et al. 2002; Wirgin et al. 2007). However, there is some disagreement among studies, and results do not include samples from all rivers inhabited by Atlantic sturgeon. Recent studies conducted indicate that genetically distinct populations of spring and fall-run Atlantic sturgeon can exist within a given river system (Balazik et al. 2017; Balazik and Musick 2015; Farrae et al. 2017).

7.2.13.3 Vocalization and Hearing

Sturgeon are known to produce sounds, especially during spawning. Lake sturgeon produce low frequency sounds during spawning bouts, principally consisting of drumming sounds that range from 5 to 8 Hz, but low frequency rumbles and hydrodynamic sounds as well as high frequency sounds have also been reported (Bocast et al. 2014). The pallid sturgeon (*Scaphirhynchus albus*) and shovelnose sturgeon (*Scaphirhynchus platorynchus*) are known to produce at least four types of sounds during the breeding season, ranging from squeaks and chirps from 1 to 2 kHz, with low frequency moans ranging in frequency between 90 and 400 Hz (Johnston and Phillips 2003). Based on these related sturgeon species, we assume Atlantic sturgeon are capable of producing both low and high frequency sounds, mostly likely during the breeding season.

While sturgeon have swim bladders, they are not known to be used hearing, and thus sturgeon appear to only rely directly on their ears for hearing. Popper (2005) reported that studies measuring responses of the ear of European sturgeon (*Acipenser sturio*) using physiological methods suggest sturgeon are likely capable of detecting sounds from below 100 Hz to about 1 kHz, indicating that sturgeon should be able to localize or determine the direction of origin of sound. Meyer and Popper (2002a) recorded auditory evoked potentials of varying frequencies and intensities for lake sturgeon (*Acipenser fulvescens*) and found that lake sturgeon can detect pure tones from 100 Hz to 2 kHz, with best hearing sensitivity from 100 to 400 Hz. They also compared these sturgeon data with comparable data for Oscar (*Astronotus ocellatus*) and goldfish (*Carassius auratus*) and reported that the auditory brainstem responses for the lake sturgeon were more similar to goldfish (which is considered a hearing specialist that can hear up to five kHz) than to the oscar (which is a non-specialist that can only detect sound up to 400 Hz); these authors, however, felt additional data were necessary before lake sturgeon could be considered specialized for hearing (Meyer and Popper 2002a). Lovell et al. (2005) also studied sound reception and the hearing abilities of paddlefish (*Polyodon spathula*) and lake sturgeon. Using a combination of morphological and physiological techniques, they determined that paddlefish and lake sturgeon were responsive to sounds ranging in frequency from 100 to 500 Hz, with the lowest hearing thresholds from frequencies in a bandwidth of between 200 and 300 Hz and higher thresholds at 100 and 500 Hz; lake sturgeon were not sensitive to sound pressure. We assume that the hearing sensitivities reported for these other species of sturgeon are representative of the hearing sensitivities of all DPSs of Atlantic sturgeon.

7.2.13.4 Status

In 2012, NMFS listed the New York Bight and Chesapeake Bay DPSs as endangered and the Gulf of Maine DPS as threatened based on low population sizes and the level of continuing threats such as degraded water quality, habitat impacts from dredging, bycatch in state and federally managed fisheries, and vessel strikes. Historically, each of these DPSs likely supported more than 10,000 spawning adults (ASSRT 2007; MSPO 1993; Secor and Niklitschek 2002). The best available data indicate that current numbers of spawning adults for each DPS are one to two orders of magnitude smaller than historical levels (ASSRT 2007; Kahnle et al. 2007). The Carolina and South Atlantic DPSs were estimated to have declined to less than three and six percent of their historical population sizes, respectively (ASSRT 2007). Both of these DPSs were listed as endangered in 2012 due to a combination of habitat curtailment and alteration, bycatch in commercial fisheries, and inadequacy of regulatory mechanisms in ameliorating these impacts and threats. The largest estimated adult Atlantic sturgeon populations are currently found in the Hudson (3,000), Altamaha (1,325), Delaware (1,305), Kennebec (865), Savannah (745), and James (705). Published estimates of Atlantic sturgeon juvenile abundance are available in the following river systems: 4,314 age 1 fish in the Hudson in 1995 (Peterson et al. 2000); 3,656 age 0-1 fish in the Delaware in 2014(Hale et al. 2016); between 1,072 to 2,033 age 1-2 fish on average from 2004-2007 in the Altamaha - (Schueller and Peterson 2010); and 154 age 1 fish in 2010 in the Satilla (Fritts et al. 2016).

7.2.13.5 Designated Critical Habitat

NMFS designated critical habitat for each ESA-listed DPS of Atlantic sturgeon in August of 2017 (Figure 38). Physical and biological features determined to be essential for Atlantic sturgeon reproduction and recruitment include (1) suitable hard bottom substrate in low salinity waters for settlement of fertilized eggs, refuge, growth, and development of early life stages, (2) transitional salinity zones for juvenile foraging and physiological development, (3) water of appropriate depth and absent physical barriers to passage, (4) unimpeded movement of adults to and from spawning sites, and (5) water quality conditions that support spawning, survival, growth, development, and recruitment.

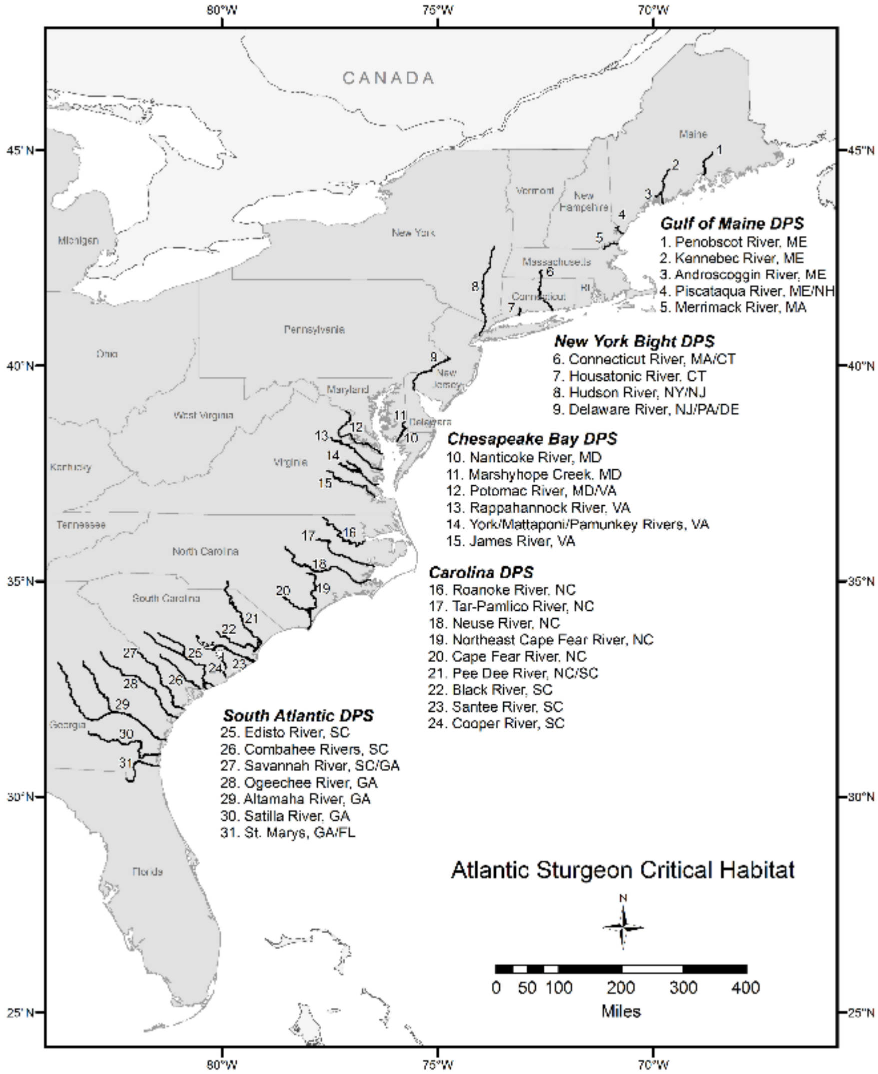


Figure 38. Map showing the 31 coastal rivers designated as critical habitat for Atlantic sturgeon.

7.2.13.6 Gulf of Maine DPS

The Gulf of Maine DPS of Atlantic sturgeon was listed as threatened on February 6, 2012. The Gulf of Maine DPS historically supported at least four spawning subpopulations; however, today it is suspected that only two extant subpopulations exist (Penobscot and Kennebec) (ASSRT 2007). The Kennebec River is the primary spawning and nursery area for Gulf of Maine Atlantic sturgeon. Ripe female Atlantic sturgeon with enlarged, fully mature eggs ready to be fertilized have been found in the Kennebec River from mid-July through early August (MSPO 1993). Prior to any commercial fishing, the Kennebec supported approximately 10,000 to 15,000 spawning adults (ASSRT 2007; MSPO 1993). The construction of the Edwards Dam in 1837 was believed to have caused the commercial sturgeon catch to decline over 50 percent (MSPO 1993). Severe pollution in the river from the 1930's through the early 1970's is also believed to have been a major factor in the continued decline of the sturgeon population in the Kennebec. In 2007, the

Atlantic Sturgeon Status Review Team concluded that, due to stressors related to poor water quality, dredging, and commercial bycatch, there was a moderate risk (i.e., greater than 50 percent chance) of the Kennebec subpopulation of Atlantic sturgeon becoming endangered within the next 20 years.

It was speculated that the Penobscot subpopulation was extirpated until a fisherman captured an adult Atlantic sturgeon in 2005, and a gill net survey directed toward Atlantic sturgeon captured seven in 2006 (ASSRT 2007). The Atlantic Sturgeon Status Review Team concluded that the Penobscot subpopulation also had a moderate risk of becoming endangered due to its potentially small size (likely less than 300 spawning adults), increased dredging projects, and poor water quality (ASSRT 2007). Within the Penobscot, substrate has been severely degraded by upstream mills, and water quality has been negatively affected by the presence of coal deposits and mercury hot spots. The potential for commercial bycatch was also viewed as a moderate threat to this subpopulation due to its small size.

7.2.13.7 New York Bight DPS

The New York Bight DPS was listed as endangered under the ESA on February 6, 2012. The New York Bight, ranging from Cape Cod to the Delmarva Peninsula, historically supported four or more spawning subpopulations, but currently this DPS only supports two known spawning subpopulations: Delaware and Hudson River. The Delaware River once supported the largest spawning subpopulation of Atlantic sturgeon in the United States, with 3,200 metric tons of landings in 1888 (ASSRT 2007; Secor and Niklitschek 2002; Secor and Waldman 1999). Population estimates based on juvenile mark and recapture studies and commercial logbook data, indicate that the Delaware subpopulation has continued to decline rapidly since 1990. Based on genetic analyses, the majority of sub adults captured in the Delaware Bay are thought to be of Hudson River origin (ASSRT 2007). However, a more recent study by Hale et al. (2016) suggests that a spawning population of Atlantic Sturgeon exists in the Delaware River and that some level of early juvenile recruitment is continuing to persist despite current depressed population levels. They estimated that 3,656 (95 percent confidence interval from 1,935 to 33,041) juveniles (ages 0 to 1) used the Delaware River estuary as a nursery in 2014. These findings suggest that the Delaware River spawning subpopulation contributes more to the New York Bight DPS than was formerly considered.

The Atlantic Sturgeon Status Review Team found that the Delaware River subpopulation had a moderately high risk (greater than 50 percent chance) of becoming endangered in the next 20 years, due to the loss of adults from ship strikes. Other stressors contributing to this conclusion that were ranked as moderate risk were dredging, water quality, and commercial bycatch (ASSRT 2007). Dredging in the upper portions of the river near Philadelphia were considered detrimental to successful Atlantic sturgeon spawning as this is suspected to be the historical spawning grounds of Atlantic sturgeon. Though dredging restrictions are in place during the spawning season, the continued degradation of suspected spawning habitat likely increases the instability of the subpopulation and could lead to its endangerment in the foreseeable future (ASSRT 2007).

The Hudson River currently supports the largest U.S. subpopulation of Atlantic sturgeon spawning adults. Historically, it supported an estimated 6,000 to 8,000 spawning females (Kahnle et al. 2007; Secor 2002). Long-term surveys indicate that the Hudson River subpopulation has been stable and/or slightly increasing since 1995 in abundance (ASSRT 2007). The Atlantic Sturgeon Status Review Team concluded that the Hudson River subpopulation had a moderate risk (less than 50 percent chance) of becoming endangered in the next 20 years due to the threat of commercial bycatch (ASSRT 2007). Other stressors, such as water quality, have improved since the 1980s and no longer seem to present a significant threat to the Hudson River population (ASSRT 2007).

7.2.13.8 Chesapeake Bay DPS

The Chesapeake Bay DPS was listed as endangered under the ESA on February 6, 2012. Historically, Atlantic sturgeon were common throughout the Chesapeake Bay and its tributaries (Kahnle et al. 1998, Wharton 1957, Bushnoe et al. 2005). Based on U.S. Fish Commission landings data, approximately 20,000 adult female Atlantic sturgeon inhabited the Chesapeake Bay and its tributaries prior to development of a commercial fishery in 1890 (Secor 2002). Chesapeake Bay rivers once supported at least six historical spawning subpopulations (ASSRT 2007), but today reproducing populations are only known to occur in the James and York Rivers. However, the presence of telemetry tagged Atlantic sturgeon in freshwater portions of Chesapeake Bay tributaries during the summer/fall spawning season (late July to mid-October) suggests that spawning may also occur in the Rappahannock, Potomac, Nanticoke, and Pocomoke Rivers.

The James River supports the largest population of Atlantic sturgeon within the DPS. Balazik et al. (2012c) reported empirical evidence that James River Atlantic sturgeon spawn in the fall, and a more recent study indicates that Atlantic sturgeon also spawn in the spring in the James River (i.e., dual spawning races) (Balazik and Musick 2015). Genetic analysis of tissue samples suggest effective populations in the James River range from around 40 to 100 (O'Leary et al. 2014). The Atlantic Sturgeon Status Review Team concluded that the James River had a moderately high risk (greater than 50 percent chance) of becoming endangered in the next 20 years, due to anticipated impacts from commercial bycatch. Dredging and ship strikes were also identified as threats (i.e., moderate risk) that contribute to the risk of extinction for the James subpopulation of Atlantic sturgeon.

The York River has a much smaller population, with annual spawning abundance estimates for 2013 of 75 (Kahn et al. 2014). The effective population size of the York River population ranges from six to 12 individuals, the smallest effective population size for any Atlantic sturgeon subpopulation along the Atlantic Coast. The total York River adult Atlantic sturgeon abundance is estimated at 289 individuals. The highest ranked stressor for the York River was commercial bycatch, which received a moderate risk rank (ASSRT 2007).

7.2.13.9 Carolina DPS

The Carolina DPS was listed as endangered under the ESA on February 6, 2012. The Carolina DPS ranges from the Albemarle Sound to the Santee-Cooper River and consists of seven extant subpopulations; one subpopulation (Sampit) is believed to be extirpated. The current abundance of these subpopulations is likely less than 3 percent of their historical abundance based on 1890s commercial landings data (ASSRT 2007; Secor and Niklitschek 2002).

Water quality issues represented either a moderate or moderately high risk for most subpopulations within this DPS (ASSRT 2007). The Pamlico Sound suffers from eutrophication and experiences periodically low dissolved oxygen events and major fish kill events, mainly in the Neuse Estuary of the Sound. The Cape Fear River is a blackwater river; however, the low dissolved oxygen concentrations in this river can also be attributed to eutrophication. Water quality is also a problem in Winyah Bay, where portions of the Bay have high concentrations of dioxins that can adversely affect sturgeon development (Chambers et al. 2012). Commercial bycatch was a concern for all of the subpopulations examined by the Atlantic Sturgeon Status Review Team. The Cape Fear and Santee-Cooper rivers were found to have a moderately high risk (greater than 50 percent) of becoming endangered within the next 20 years due to impeded habitat from dams. The Cape Fear and Santee-Cooper are the most impeded rivers along the range of the species, where dams are located in the lower coastal plain and impede between 62 to 66 percent of the habitat available between the fall line and mouth of the river (ASSRT 2007). The Atlantic Sturgeon Status Review Team concluded that the limited habitat in which sturgeon could spawn and utilize for nursery habitat in these rivers likely leads to the instability of these subpopulations and to the entire DPS being at risk of endangerment.

7.2.13.10 South Atlantic DPS

The South Atlantic DPS was listed as endangered under the ESA on February 6, 2012. This DPS historically supported eight spawning subpopulations but currently supports five extant spawning subpopulations (ASSRT 2007). The Altamaha and the Ashepoo, Combahee and Edisto Basin subpopulations support the largest number of spawning adults. The current abundance of these subpopulations are suspected to be less than six percent of their historical abundance, extrapolated from the 1890s commercial landings (ASSRT 2007; Secor and Niklitschek 2002). Peterson et al. (2008) reported that approximately 324 and 386 adults per year returned to the Altamaha River in 2004 and 2005, respectively. Few captures have been documented in subpopulations other than the Altamaha and the Ashepoo, Combahee and Edisto Basin within this DPS, and these smaller systems are suspected to contain less than one percent of their historic abundance (ASSRT 2007). The Atlantic Sturgeon Status Review Team found that the South Atlantic DPS of Atlantic sturgeon had a moderate risk (greater than 50 percent) of becoming endangered in the next 20 years due primarily to dredging, degraded water quality, and commercial fisheries bycatch.

7.2.14 Giant Manta Ray

The giant manta ray is an elasmobranch species that occupies tropical, subtropical, and temperate oceanic waters and productive coastlines (Figure 39).

Figure 39: Map depicting the range of the giant manta ray [adapted from Lawson et al. (2017)].

Giant manta rays a diamond-shaped body with wing-like pectoral fins measuring up to 25 ft (8 m) across. On January 22, 2018, NOAA Fisheries published a final rule listing the giant manta ray (*Manta birostris*) as threatened under the ESA.

We used information available in the 2017 Status Review (Miller and Klimovich 2017b), the final ESA-listing rule, and the scientific literature to summarize the life history, population dynamics, and status of the species, as follows.

7.2.14.1 Life History

Giant manta rays reach sexual maturity at about 10 years old. They are viviparous, giving birth to one pup every two to three years. Gestation lasts between 12 to 13 months. Giant manta rays can live up to 40 years, so a female may only produce between five to 15 pups in a lifetime (FAO 2012).

Giant manta rays are migratory, capable of undertaking migrations up to 1,500 km (Graham et al. 2012; Hearn et al. 2014), although some tagged individuals have been observed staying in the same location (Stewart et al. 2016). Giant manta rays have been observed in aggregations of 100 to 1,000 individuals (Miller and Klimovich 2017b; Notarbartolo-di-Sciara and Hillyer 1989), at particular sites. These sites are thought to be feeding or cleaning locations, or where courtships take place.

Giant manta rays are planktivores, using gill plates (also known as gill rakers) to feed on zooplankton. They conduct night descents to between 200 and 450 m, and can even dive to depths of over 1,000 m. During the day, they can also be found feeding in shallow waters (less than 10 m) (Miller and Klimovich 2017b).

7.2.14.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the giant manta ray.

There are no current or historical estimates of range-wide abundance, although there are some rough estimates of subpopulation size based on anecdotal accounts from fishermen and divers. It is difficult to obtain reliable abundance estimates as the species is only sporadically observed. There are about 11 subpopulations estimates worldwide (perhaps more), and these subpopulation estimates range from 100 to 1,500 individuals each (FAO 2012; Miller and Klimovich 2017b). The only abundance data for giant manta rays in the Atlantic comes from two sources; the Flower Garden Banks Marine Sanctuary in the Gulf of Mexico, with more than 70 individuals, and in the waters off Brazil, with about 60 individuals (Miller and Klimovich 2017b).

There is not a great deal of information on the population structure of giant manta ray. Some evidence suggests that there are isolated subpopulations (Stewart et al. 2016), and possibly a subspecies resident to the Yucatán (Hinojosa-Alvarez et al. 2016).

Data on population trends globally are largely unavailable. However, there have been decreases in landings of up to 95 percent in the Indo-Pacific, though these declines have not been observed in other subpopulations such as Mozambique and Ecuador (Miller and Klimovich 2017b).

Giant manta rays are commonly found offshore in oceanic waters, but are sometimes found in shallow waters (less than 10 m) during the day (Lawson et al. 2017; Miller and Klimovich 2017b). In the Atlantic Ocean, giant manta rays have been observed as far north as New Jersey.

7.2.14.3 Vocalization and Hearing

Giant manta rays are elasmobranchs, and although there is no known information on their sound production and hearing abilities, these abilities have been studied in other elasmobranchs species. Elasmobranchs, like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005b; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders, and thus are unable to detect sound pressure (Casper et al. 2012b). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001). Data for elasmobranchs fishes suggest they can detect sound between 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012b; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009a; Ladich and Fay 2013a; Myrberg 2001).

7.2.14.4 Status

The Status Review found that giant manta rays are at risk throughout a significant portion of their range, due in large part to the observed declines in the Indo-Pacific. There are few known natural threats to giant manta rays. Disease and shark attacks were ranked as low risk threats, and giant manta rays exhibit high survival rates after maturity (Miller and Klimovich 2017b).

The most significant threat to giant manta ray populations is commercial fishing. Giant manta rays are a targeted species for the mobuild gill raker market. Gills from mobuilds (i.e., rays of the genus *Mobula*, including *Manta* spp.) are dried and sold in Asian dried seafood and traditional Chinese medicine markets (O'Malley et al. 2017). Sources for gill rakers sold in these markets include China, Indonesia, Vietnam, Sri Lanka, and India; one market in Guangzhou, China, accounts for about 99 percent of the total market volume. In 2011, there was an estimated 60.5 tons of mobuild gill rakers, which almost doubled to 120.5 tons in 2015 (O'Malley et al. 2017).

In addition to the threat from directed fishing, giant manta rays are also captured incidentally in industrial purse seine and artisanal gillnet fisheries. Incidental bycatch is a particular concern in the eastern Pacific Ocean, and the Indo-Pacific (Miller and Klimovich 2017b).

7.2.14.5 Designated Critical Habitat

No critical habitat has been designated for the giant manta ray.

7.2.14.6 Recovery Goals

NMFS has not prepared a recovery plan for the giant manta ray.

7.2.15 Gulf Sturgeon

The Gulf sturgeon was listed as threatened on September 30, 1991. NMFS and the U.S. Fish and Wildlife Service jointly manage Gulf sturgeon under the ESA. NMFS is responsible for consultations on actions affecting Gulf sturgeon and their critical habitat in marine habitats. The U.S. Fish and Wildlife Service is responsible for Gulf sturgeon consultations in riverine habitats. In estuarine habitats, responsibility is divided based on the action agency involved: the U.S. Fish and Wildlife Service consults with the Department of Transportation, the U.S. Environmental Protection Agency, the U.S. Coast Guard, and the Federal Emergency Management Agency; NMFS consults with the Department of Defense, U.S. Army Corps of Engineers, the Bureau of Ocean Energy Management, and any other federal agencies not specifically mentioned at 50 CFR 226.214. In 2009, NMFS and the U.S. Fish and Wildlife Service conducted a 5-year review and found Gulf sturgeon continued to meet the definition of a threatened species (USFWS and NMFS 2009).

The current range of the Gulf sturgeon extends from Lake Pontchartrain in Louisiana east to the Suwannee river system in Florida (Figure 40). Within that range, seven major rivers are known to support reproducing populations: Pearl, Pascagoula, Escambia, Yellow, Choctawhatchee, Apalachicola, and Suwannee (USFWS and NMFS 2009).

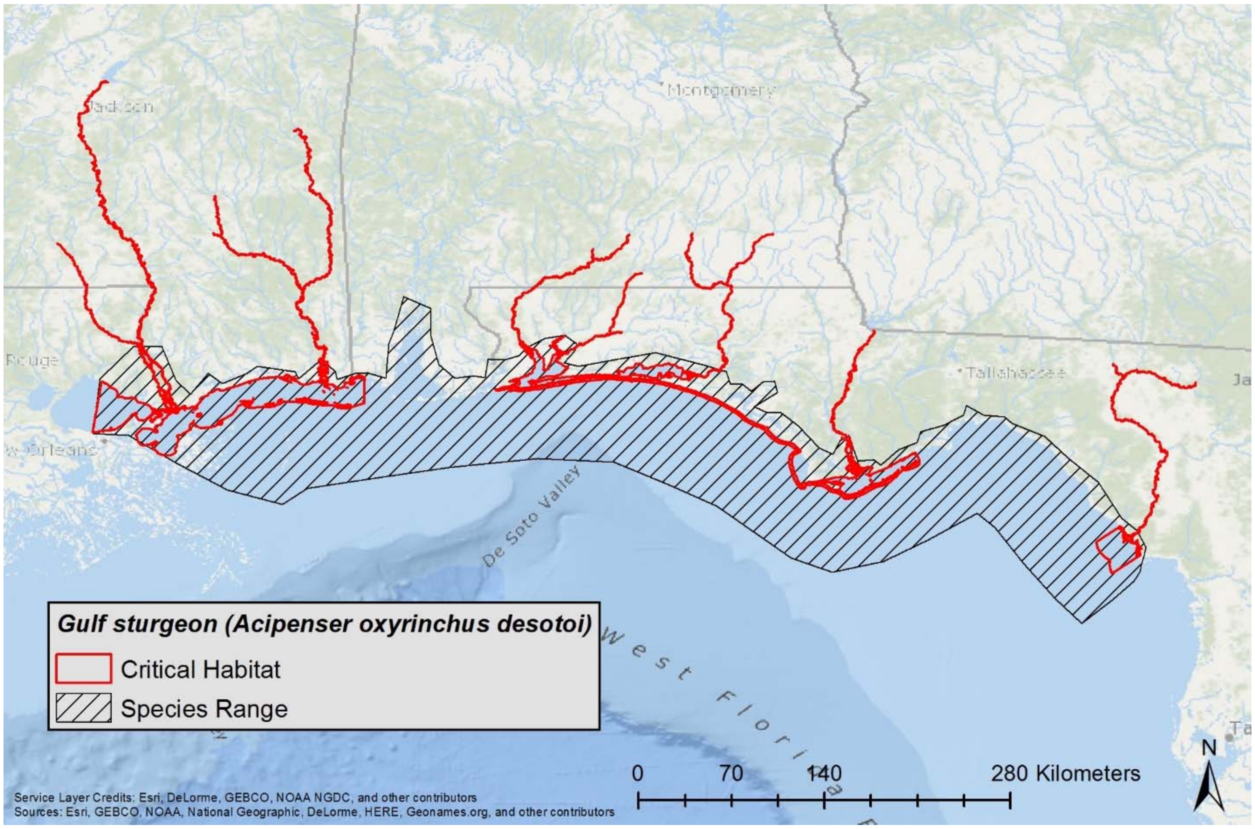


Figure 40: Geographic range and designated critical habitat of the Gulf sturgeon.

Gulf sturgeon are benthic fusiform fish with an extended snout, vertical mouth, five rows of scutes (bony plates surrounding the body), four barbels (slender, whisker-like feelers anterior to the mouth used for touch and taste), and a heterocercal (upper lobe is longer than lower) caudal fin. Adults range from 6 to 8 ft in length and weigh up to 200 pounds; females grow larger than males (USFWS and NMFS 2009).

We used information available in the most recent status review (USFWS and NMFS 2009) and the scientific literature summarize the life history, population dynamics, and status of the species, as follows.

7.2.15.1 Life history

Gulf sturgeon are long-lived, with some individuals reaching at least 42 years in age. Surveys in the Suwannee River suggest that a more common maximum age may be around 25 years (Sulak and Clugston 1999). Age at sexual maturity for females ranges from 8 to 17 years, and for males from 7 to 21 years (Huff 1975). In general, Gulf sturgeon spawn up-river in spring, spend winter months in near-shore marine environments, and utilize pre- and post-spawn staging and nursery areas in the lower rivers and estuaries (Heise et al. 2005; Heise et al. 2004). There is some evidence of autumn spawning in the Suwannee River, however there is uncertainty as to whether this spawning is due to environmental conditions or represents a genetically distinct population (Randall and Sulak 2012). Gulf sturgeon spawn at intervals ranging from 3 to 5 years for females and 1 to 5 years for males (Fox et al. 2000; Smith 1985). The spring migration to up-river spawning sites begins in mid-February and continues through May. Fertilization is external; females deposit their eggs in the upper reaches of and show preference for hard, clean substrate (e.g., bedrock covered in gravel and small cobble).

Upon hatching from their eggs, Gulf sturgeon larvae spend the first few days of life sheltered in interstitial spaces at the spawning site (Kynard and Parker 2004). At the onset of feeding, age-0 Gulf sturgeon disperse and are often found on shallow sandbars and rippled sand shoals (less than 4 m depth) (Sulak and Clugston 1998). Young-of-the-year spend 6 to 10 months slowing working their way downstream feeding on aquatic insects (e.g., mayflies and caddisflies), worms (oligochaetes), and bivalve mollusks, and arrive in estuaries and river mouths by mid-winter (Sulak and Clugston 1999) where they will spend their next 6 years developing. After spawning, adult Gulf sturgeon migrate downstream to summer resting and holding areas in the mid to lower reaches of the rivers where they may hold until November (Wooley and Crateau 1985). While in freshwater adults lose a substantial amount of their weight, but regain it upon entering the estuaries. Sub adult and non-spawning adults also spend late spring through fall in these holding areas (Foster and Clugston 1997). By early December all adult and sub-adult Gulf sturgeon return to the marine environment to forage on benthic (bottom dwelling) invertebrates along the shallow nearshore (2 to 4 m depth), barrier island passes, and in unknown off-shore locations in the gulf (Carr et al. 1996; Fox et al. 2002; Huff 1975; Ross et al. 2009). Juvenile Gulf sturgeon overwinter in estuaries, river mouths, and bays; juveniles do not enter the nearshore/offshore marine environments until around age 6 (Sulak and Clugston 1999). Gulf sturgeon show a high degree of river-specific fidelity (Rudd et al. 2014). Adult and sub-adult Gulf sturgeon fast while in freshwater environments and are almost entirely dependent on the estuarine/marine environment for food (Gu et al. 2001; Wooley and Crateau 1985). Some juveniles (ages 1 to 6) will also fast in the freshwater summer holding areas, but the majority feed year round in the estuaries, river mouths, and bays (Sulak et al. 2009).

7.2.15.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Gulf Sturgeon.

Currently, seven rivers are known to support reproducing populations of Gulf sturgeon. The most recent abundance estimates were reported in the 5-Year Status Review conducted in 2009 (USFWS and NMFS 2009). The largest estimated populations of Gulf sturgeon are found in the Suwannee (14,000), the Choctawhatchee (3,314), and the Yellow (911) rivers (USFWS and NMFS 2009). The most recent population estimates for the other four rivers with known reproducing populations are all below 500.

Gulf sturgeon abundance trends are typically assessed on a riverine basis. In general, Gulf sturgeon populations in the eastern portion of the range appear to be stable or slightly increasing, while populations in the western portion are associated with lower abundances and higher uncertainty (USFWS and NMFS 2009). Pine and Martell (2009) reported that, due to low recapture rates and sparse data, the population viability of Gulf sturgeon is currently uncertain.

When grouped by genetic relatedness, five regional or river-specific stocks emerge: (1) Lake Pontchartrain and Pearl River; (2) Pascagoula River; (3) Escambia, Blackwater and Yellow Rivers; (4) Choctawhatchee River; and (5) Apalachicola, Ochlocknee and Suwanee Rivers (Rudd et al. 2014; Stabile et al. 1996). Gene flow is low in Gulf sturgeon stocks, with each stock exchanging less than one mature female per generation (Waldman and Wirgin 1998).

7.2.15.3 Vocalization and Hearing

Sturgeon are known to produce sounds, especially during spawning. Lake sturgeon produce low frequency sounds during spawning bouts, principally consisting of drumming sounds that range from 5 to 8 Hz, but low frequency rumbles and hydrodynamic sounds as well as high frequency sounds have also been reported (Bocast et al. 2014). The pallid sturgeon (*Scaphirhynchus albus*) and shovelnose sturgeon (*Scaphirhynchus platorynchus*) are known to produce at least four types of sounds during the breeding season, ranging from squeaks and chirps from 1 to 2 kHz, with low frequency moans ranging in frequency between 90 and 400 Hz (Johnston and Phillips 2003). Based on these related sturgeon species, we assume Gulf sturgeon are capable of producing both low and high frequency sounds, mostly likely during the breeding season.

While sturgeon have swim bladders, they are not known to be used hearing, and thus sturgeon appear to only rely directly on their ears for hearing. Popper (2005) reported that studies measuring responses of the ear of European sturgeon (*Acipenser sturio*) using physiological methods suggest sturgeon are likely capable of detecting sounds from below 100 Hz to about 1 kHz, indicating that sturgeon should be able to localize or determine the direction of origin of sound. Meyer and Popper (2002a) recorded auditory evoked potentials of varying frequencies and intensities for lake sturgeon (*Acipenser fulvescens*) and found that lake sturgeon can detect pure tones from 100 Hz to 2 kHz, with best hearing sensitivity from 100 to 400 Hz. They also compared these sturgeon data with comparable data for Oscar (*Astronotus ocellatus*) and goldfish (*Carassius auratus*) and reported that the auditory brainstem responses for the lake sturgeon were more similar to goldfish (which is considered a hearing specialist that can hear up to five kHz) than to the oscar (which is a non-specialist that can only detect sound up to 400 Hz); these authors, however, felt additional data were necessary before lake sturgeon could be considered specialized for hearing (Meyer and Popper 2002a). Lovell et al. (2005) also studied sound reception and the hearing abilities of paddlefish (*Polyodon spathula*) and lake sturgeon. Using a combination of morphological and physiological techniques, they determined that paddlefish and lake sturgeon were responsive to sounds ranging in frequency from 100 to 500 Hz, with the lowest hearing thresholds from frequencies in a bandwidth of between 200 and 300 Hz and higher thresholds at 100 and 500 Hz; lake sturgeon were not sensitive to sound pressure. We assume that the hearing sensitivities reported for these other species of sturgeon are representative of the hearing sensitivities of Gulf sturgeon.

7.2.15.4 Status

The decline in the abundance of Gulf sturgeon has been attributed to targeted fisheries in the late 19th and early 20th centuries, habitat loss associated with dams and sills, habitat degradation associated with dredging, de-snagging, and contamination by pesticides, heavy metals, and other industrial contaminants, and certain life history characteristics (e.g., slow growth and late maturation). Effects of climate change (warmer water, sea level rise and higher salinity levels) could lead to accelerated changes in habitats utilized by Gulf sturgeon. The rate that climate change and corollary impacts are occurring may outpace the ability of the Gulf sturgeon to adapt given its limited geographic distribution and low dispersal rate. In general, Gulf sturgeon populations in the eastern portion of the range appear to be stable or slightly increasing, while populations in the western portion are associated with lower abundances and higher uncertainty (USFWS and NMFS 2009).

7.2.15.5 Critical Habitat

Designated critical habitat for Gulf sturgeon was established in 2003 and consists of 14 geographic units encompassing 2,783 river km as well as 6,042 square km of estuarine and marine habitat (Figure 40). Primary constituent elements for the conservation of Gulf Sturgeon are abundant food items, riverine spawning sites with substrates suitable for egg deposition and development, riverine aggregation areas, a flow regime necessary for normal behavior, growth, and survival, water and sediment quality necessary for normal behavior, growth, and viability of all life stages, and safe and unobstructed migratory pathways.

7.2.15.6 Recovery Goals

The 1995 Recovery Plan outlined three recovery objectives: (1) to prevent further reduction of existing wild populations of Gulf sturgeon within the range of the subspecies; (2) to establish population levels that would allow delisting of the Gulf sturgeon by management units (management units could be delisted by 2023 if required criteria are met); (3) to establish, following delisting, a self-sustaining population that could withstand directed fishing pressure within management units (USFWS and GSMFC 1995). The most recent Gulf sturgeon 5-year review recommended that criteria be developed in a revised recovery plan (USFWS and NMFS 2009).

7.2.16 Oceanic Whitetip Shark

The oceanic whitetip shark is distributed worldwide in tropical and subtropical waters between 10° North and 10° South, usually found in open ocean and near the outer continental shelf (Figure 41).

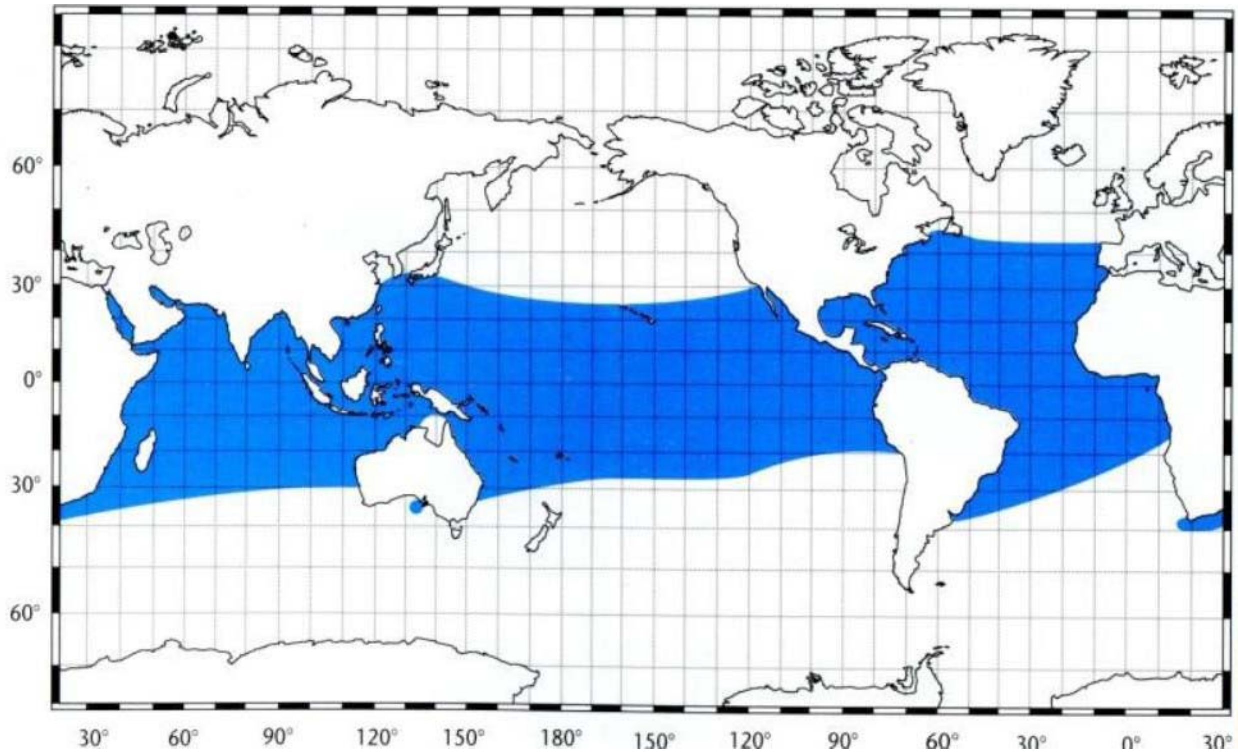


Figure 41: Geographic range of the oceanic whitetip shark [adapted from Last and Stevens (2009)].

Oceanic whitetip sharks have very long and wide paddle-shaped pectoral fins with characteristic mottled white tips (also present on the front dorsal and caudal fins). Its body is grayish bronze to brown, and white underneath. Adults can grow up to 3.4 m and 230 kilograms. The oceanic whitetip shark was listed as threatened under the ESA on January 30, 2018.

We used information available in the 2017 Status Review (Young et al. 2017), the final ESA-listing rule, and the scientific literature to summarize the life history, population dynamics, and status of the species, as follows.

7.2.16.1 Life History

The oceanic whitetip shark gives birth to live young (i.e., "viviparous"). Their reproductive cycle is thought to be biennial, giving birth on alternate years, after a lengthy 10 to 12-month gestation period. The number of pups in a litter ranges from one to 14 (mean = 6), and a positive correlation between female size and number of pups per litter has been observed, with larger sharks producing more offspring (Bonfil et al. 2008; Compagno 1984; IOTC 2014; Seki et al. 1998). Not a great deal is known about oceanic whitetip sharks' lifespan. Estimates range from 12 to 13 years (Lessa et al. 1999; Seki et al. 1998), to 17 years, and even up to 20 years old

(Young et al. 2017). They are a slow-growing species, and growth rates are believed to be similar between the sexes (Joung et al. 2016; Lessa et al. 1999; Seki et al. 1998; Young et al. 2017). Age at maturity varies by ocean region, with six to seven years old recorded in the southwest Atlantic, and four to nine years old in the North Pacific, with the sexes having similar ages at maturity (Joung et al. 2016; Lessa et al. 1999; Seki et al. 1998).

Little is known about the movement or possible migration paths of the oceanic whitetip shark. Although the species is considered highly migratory and capable of making long distance movements, tagging data provides evidence that this species also exhibits a high degree of philopatry (i.e., site fidelity) in some locations. In the Atlantic, young oceanic whitetip sharks have been found well offshore along the southeastern coast of the U.S., suggesting that there may be a nursery in oceanic waters over this continental shelf (Bonfil et al. 2008; Compagno 1984). In the southwestern Atlantic, the prevalence of immature sharks, both female and male, in fisheries catch data suggests that this area may serve as potential nursery habitat for the oceanic whitetip shark (Coelho et al. 2009; Frédou et al. 2015; Tambourgi et al. 2013; Tolotti et al. 2015). Juveniles seem to be concentrated in equatorial latitudes, while specimens in other maturational stages are more widespread (Tambourgi et al. 2013). Pregnant females are often found close to shore, particularly around the Caribbean Islands.

Oceanic whitetip sharks are regarded as opportunistic feeders, eating teleosts (bony fishes) and cephalopods. Large pelagic fish species commonly found in the stomachs of oceanic whitetips include, blackfin tuna, white marlin, and barracuda.

7.2.16.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the oceanic whitetip shark.

There is no range-wide abundance estimate available for oceanic whitetip sharks. However, the species was once one of the most abundant sharks in the ocean. Catch data from individual ocean basins indicate that the populations have undergone significant declines (Young et al. 2017). In the Northwest Atlantic and Gulf of Mexico, declines are estimated to be between 57 and 88 percent (Young et al. 2017). Populations in the Eastern Pacific Ocean are thought to have declined between 80 and 90 percent since the late 1990s (Hall 2013). Although generally not targeted, due to their vertical and horizontal distribution oceanic whitetip sharks are frequently caught as bycatch in many fisheries, including pelagic longline fisheries targeting tuna and swordfish, purse seine, gillnet, and artisanal fisheries. They are also a preferred species for their large, morphologically distinct fins, as they obtain a high price in the Asian fin market.

While there is limited research on the genetic diversity of oceanic whitetip sharks, that which exists indicates low genetic diversity. Compared to other pelagic sharks (e.g., silky sharks (*Carcharhinus falciformis*), oceanic whitetip sharks display relatively low mitochondrial DNA genetic diversity (Camargo et al. 2016; Clarke et al. 2015; Ruck 2016). As noted previously, the species appears to display a high degree of philopatry to certain sites, with females giving birth on one side of a basin or the other, indicating little if any mixing with individuals of other regions (Howey-Jordan et al. 2013; Tolotti et al. 2015; Young et al. 2017). Thermal barriers (i.e., water temperatures less than 15° Celsius) may prevent inter-ocean basin movements. Based in genetic analyses, there is significant population structuring between the Western Atlantic and Indo-Pacific Ocean populations (Ruck 2016).

Oceanic whitetip sharks are distributed throughout open ocean waters, the outer continental shelf, and around oceanic islands, primarily from 10° North to 10° South, but up to 30° North and 35° South (Young et al. 2017). They can be found at the ocean surface and down to at least 152 m deep, but most frequently stay between depths of 25.5 and 50 m (Carlson and Gulak 2012; Young et al. 2017). They display a preference for water temperatures above 20° Celsius, but can be found in waters between 15° and 28° Celsius, and can briefly tolerate waters as cold as 7.75° Celsius during dives to the mesopelagic zone (Howey-Jordan et al. 2013; Howey et al. 2016).

In the Western Atlantic, oceanic whitetips occur from Maine to Argentina, including the Caribbean and Gulf of Mexico. Essential Fish Habitat for the oceanic whitetip shark includes localized areas in the central Gulf of Mexico and Florida Keys, and depths greater than 200 m in the Atlantic (from southern New England to Florida, Puerto Rico, and the U.S. Virgin Islands). In the Northwest Atlantic, historically the species was widespread, abundant, and the most common pelagic shark warm waters (Backus et al. 1956). However, recent information suggests the species is now relatively rare in this region (Young et al. 2017).

7.2.16.3 Vocalization and Hearing

Oceanic whitetip sharks are elasmobranchs and like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005b; Myrberg 2001; Myrberg et al. 1978; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders, and thus are unable to detect sound pressure (Casper et al. 2012b). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001).

Data for elasmobranchs fishes suggest they can detect sound between 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012b; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009a; Ladich and Fay 2013a; Myrberg 2001). Studies involving oceanic whitetip sharks show attraction to low frequency sounds, particularly those between 25 and 50 Hz, with less but still noticeable attraction at higher frequencies between 500 and 1,000 Hz (Myrberg 2001; Myrberg et al. 1975a; Myrberg et al. 1975b; Myrberg et al. 1976; Myrberg et al. 1978).

7.2.16.4 Status

In addition to declines in oceanic whitetip catches throughout its range, there is also evidence of declining average size over time in some areas, and is a concern for the species' status given evidence that litter size is potentially correlated with maternal length. Such extensive declines in the species' global abundance and the ongoing threat of overutilization, the species' slow growth and relatively low productivity, makes them generally vulnerable to depletion and potentially slow to recover from overexploitation. Related to this, the low genetic diversity of oceanic whitetip sharks is also cause for concern and a viable risk over the foreseeable future for this species. Loss of genetic diversity can lead to reduced fitness and a limited ability to adapt to a rapidly changing environment. The biology of the oceanic whitetip shark indicates that it is likely to be a species with low resilience to fishing and minimal capacity for compensation (Rice and Harley 2012).

7.2.16.5 Critical Habitat

No critical habitat has been designated for the oceanic whitetip shark.

7.2.16.6 Recovery Goals

NMFS has not prepared a recovery plan for the oceanic whitetip shark.

7.2.17 Scalloped Hammerhead Shark – Central and Southwest Atlantic DPS

Scalloped hammerheads are moderately large coastal pelagic sharks found worldwide in coastal warm temperate and tropical seas in the Atlantic, Pacific and Indian Oceans between 46°N and 36°S (Miller et al. 2014a) (Figure 42). Four scalloped hammerhead shark DPSs were listed in July 2014: Eastern Pacific DPS and Eastern Atlantic DPS (entirely foreign) were listed as endangered and the Central and Southwest Atlantic DPS and Indo-West Pacific DPS were listed as threatened. Only the Central and Southwest Atlantic DPS is found in the action area.

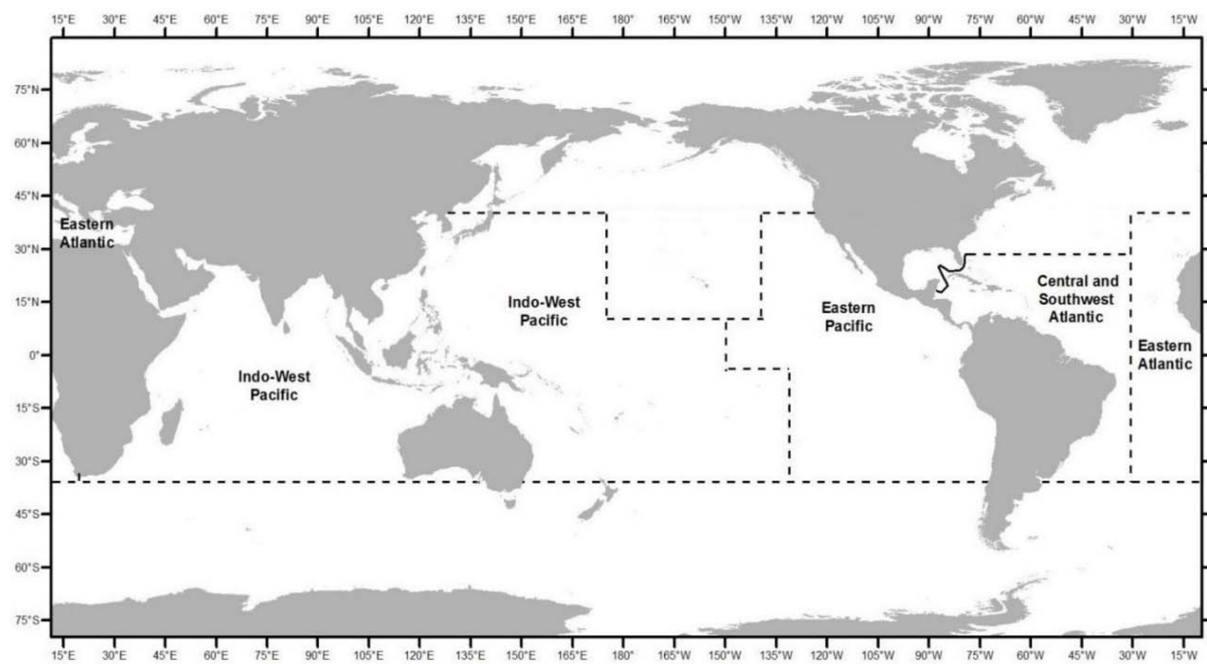


Figure 42. Map depicting the DPSs for the scalloped hammerhead shark.

Hammerhead sharks are recognized by their laterally expanded head that resembles a hammer, hence the common name "hammerhead." The scalloped hammerhead shark is distinguished from other hammerheads by a noticeable indentation on the center and front portion of the head, along with two more indentations on each side of this central indentation, giving the head a “scalloped” appearance. It has a broadly arched mouth and the back of the head is slightly swept backward.

We used information available in the 2014 recent status review (Miller et al. 2014a), the final ESA-listing rule, and the scientific literature to summarize the life history, population dynamics, and status of the species, as follows.

7.2.17.1 Life History

The scalloped hammerhead shark gives birth to live young (i.e., “viviparous”), with a gestation period of nine to 12 months (Branstetter 1987; Stevens and Lyle 1989) which may be followed by a one-year resting period (Liu and Chen 1999). Females attain maturity around 2.0 to 2.5 m in length, while males reach maturity at smaller sizes between 1.3 to 2.0 m. The age at maturity differs by region. For example, in the Gulf of Mexico, Branstetter (1987) estimated that females mature at about 15 years of age and males at around nine to 10 years of age. In northeastern Taiwan, Chen et al. (1990) calculated age at maturity to be four years for females and 3.8 years for males. On the east coast of South Africa, age at sexual maturity for females was estimated at 11 years (Dudley and Simpfendorfer 2006). Parturition, however, does not appear to vary by region and may be partially seasonal (Harry et al. 2011), with neonates present year round but with abundance peaking during the spring and summer months (Adams and Paperno 2007; Duncan and Holland 2006; Harry et al. 2011; Noriega et al. 2011). Females move inshore to birth, with litter sizes anywhere between one and 41 live pups. Off the coast of northeastern Australia, Noriega et al. (2011) found a positive correlation between litter size and female shark length, as did White et al. (2008) in Indonesian waters. However, off the northeastern coast of Brazil, Hazin et al. (2001) found no such relationship. Size at birth is estimated between 0.3 to 0.6 m.

Scalloped hammerheads are found over continental shelves and the shelves surrounding islands, as well as adjacent deep waters, but is seldom found in waters cooler than 22° Celsius (Compagno 1984; Schulze-Haugen and Kohler 2003). They range from the intertidal and surface to depths of up to 450-512 m (Klimley 1993), with occasional dives to even deeper waters (Jorgensen et al. 2009). They have also been documented entering enclosed bays and estuaries (Compagno 1984). Neonates and juveniles inhabit nearshore nursery habitats for up to one year or more as these areas provide valuable refuge from predation (Duncan and Holland 2006). They are high trophic level, opportunistic predators whose diet includes crustaceans, fish and cephalopods.

7.2.17.2 Population Dynamics

The following is a discussion of the species’ population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Central and Southwest Atlantic DPS of Scalloped Hammerhead sharks.

Scalloped hammerhead sharks are highly mobile and partly migratory and are likely the most abundant of the hammerhead species (Maguire 2006); however the risk of local depletions is of concern. Scalloped hammerhead sharks have a life history that is susceptible to overharvesting, and according to the most recent stock assessment the Northwestern Atlantic and Gulf of Mexico stock has declined to a relatively low level of abundance in recent years (Hayes et al. 2009). Populations in other parts of the world are assumed to have suffered similar declines, however data to conduct stock assessments on those populations are currently lacking.

Based on information related to genetic variation among populations, behavior and physical factors, and differences in international regulatory mechanisms, the scalloped hammerhead Extinction Risk Analysis team identified six DPSs: Northwest Atlantic and Gulf of Mexico; Central and Southwest Atlantic; Eastern Atlantic; Indo-West Pacific; Central Pacific; and Eastern Pacific (Miller et al. 2014a).

7.2.17.3 Vocalization and Hearing

Scalloped hammerhead sharks are elasmobranchs and like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005b; Myrberg 2001; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swimbladders, and thus are unable to detect sound pressure (Casper et al. 2012b). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001).

Data for elasmobranchs fishes, including scalloped hammerheads, suggest they can detect sound between 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012b; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009a; Ladich and Fay 2013a; Myrberg 1978; Myrberg 2001; Olla 1962). A study involving unidentified hammerhead sharks of the genus *Sphyrna*, indicates attraction to low frequency sound between 20 and 60 Hz (Nelson and Gruber 1963). However, a study specifically on scalloped hammerheads found no attraction to similar low frequency sound (Klimley and Nelson. 1981).

7.2.17.4 Status

Based on a combination of fisheries dependent and fisheries independent data, it is estimated that hammerhead shark populations have experienced drastic population declines, in excess of 90 percent, in several parts of their global range (Gallagher et al. 2014). While scalloped hammerhead sharks in the northwest Atlantic may currently be in a rebuilding phase, populations found further south in the Atlantic could still be in danger of decline (Miller et al. 2014a). Historical landings data indicate that large numbers of hammerhead sharks were removed by longliners off the coast of Brazil in the late 20th century (Amorim et al. 1998). Although abundance estimates and quality catch data are unavailable for this DPS, the evidence of heavy fishing pressure on this species off the coast of Brazil, Central America, and the Caribbean, with documented large numbers of juvenile and neonate landings, suggests this DPS is likely approaching a level of abundance and productivity that places its current and future persistence in question (Miller et al. 2014a). Overutilization by industrial/commercial fisheries combined with high at-vessel fishing mortality were ranked by the Extinction Risk Analysis team as the greatest risks to the persistence of this DPS. Overutilization by artisanal fisheries, lack of adequate regulatory mechanisms, illegal, unreported and unregulated fishing, and the schooling behavior of the species were ranked as moderate risks.

7.2.17.5 Critical Habitat

No critical habitat has been designated for the scalloped hammerhead shark.

7.2.17.6 Recovery Goals

NMFS has not prepared a recovery plan for the scalloped hammerhead shark.

7.2.18 Smalltooth Sawfish – United States Portion of Range DPS

The smalltooth sawfish is a tropical marine and estuarine elasmobranch. Within the United States, smalltooth sawfish have been captured in estuarine and coastal waters from New York southward through Texas, although peninsular Florida has historically been the region of the United States with the largest number of recorded captures (NMFS 2010c) (Figure 43).

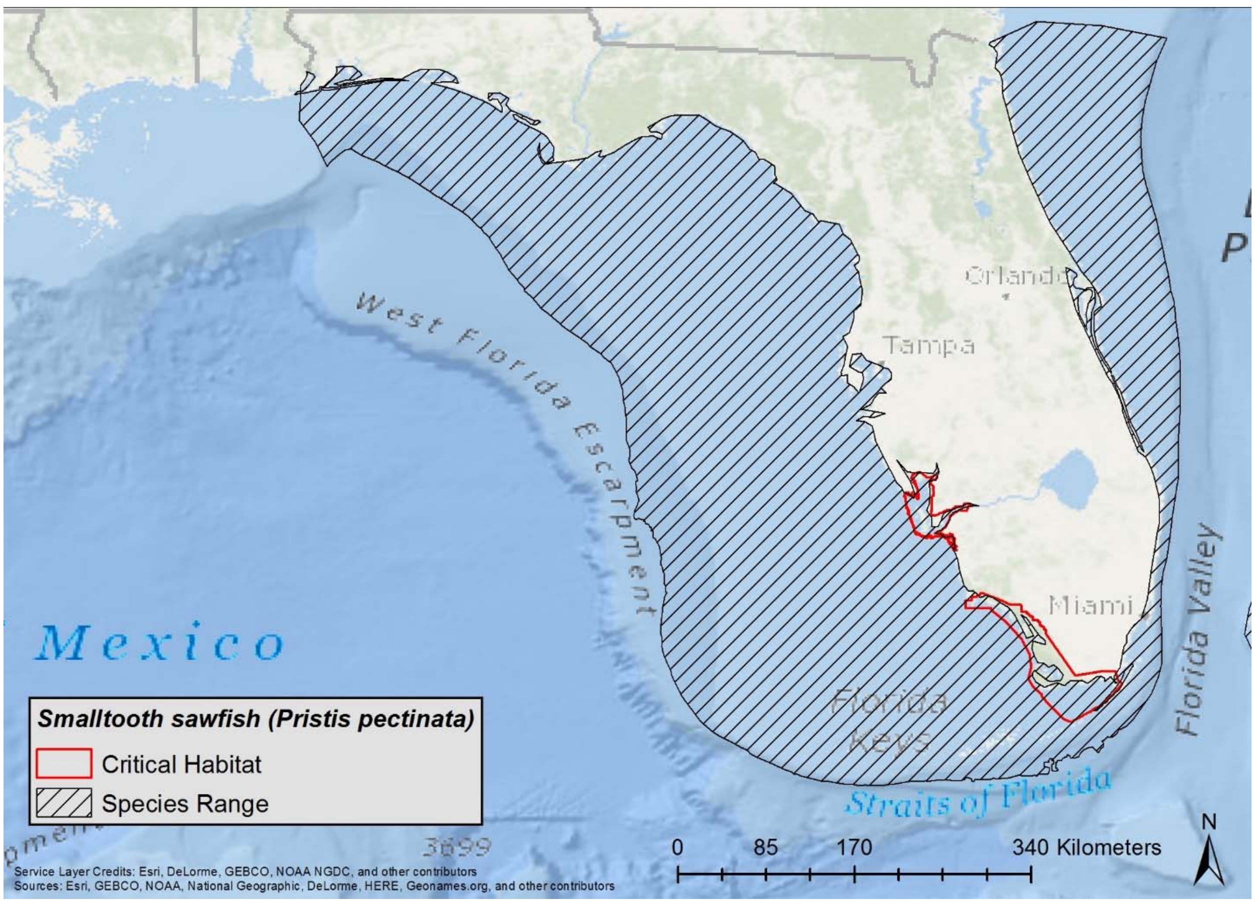


Figure 43: Map depicting the range and designated critical habitat for the United States DPS of smalltooth sawfish.

Although they are rays, sawfish physically resemble sharks, with only the trunk and especially the head ventrally flattened. Smalltooth sawfish are characterized by their "saw," a long, narrow, flattened rostral blade with a series of transverse teeth along either edge. The U.S. DPS of smalltooth sawfish was listed as endangered under the ESA effective May 1, 2003.

7.2.18.1 Life History

Smalltooth sawfish size at sexual maturity has been reported as 360 cm total length by Simpfendorfer (2005). Carlson and Simpfendorfer (2015) estimated that sexual maturity for females occurs between seven and 11 years of age. Smalltooth sawfish are viviparous with fertilization being internal. The gestation period for smalltooth sawfish is estimated at five months based on data from the largetooth sawfish (Thorson 1976). Females move into shallow estuarine and nearshore nursery areas to give birth to live young between November and July, with peak parturition occurring between April and May (Poulakis et al. 2011). Litter sizes range between 10 and 20 individuals (Bigalow and Schroeder 1953; Carlson and Simpfendorfer 2015; Simpfendorfer 2005).

Neonate smalltooth sawfish are born measuring 67 to 81 cm total length and spend the majority of their time in the shallow nearshore edges of sand and mud banks (Poulakis et al. 2011; Simpfendorfer et al. 2010). Once individuals reach 100 to 140 cm total length, they begin to expand their foraging range. Capture data suggests smalltooth sawfish in this size class may move throughout rivers and estuaries within a salinity range of 18 and 30 (practical salinity units). Individuals in this size class also appear to have the highest affinity to mangrove habitat (Simpfendorfer et al. 2011). Juvenile sawfish spend the first two to three years of their lives in the shallow waters provided in the lower reaches of rivers, estuaries, and coastal bays (Simpfendorfer et al. 2008; Simpfendorfer et al. 2011). As smalltooth sawfish approach 250 cm total length they become less sensitive to salinity changes and begin to move out of the protected shallow-water embayments and into the shorelines of barrier islands (Poulakis et al. 2011). Adult sawfish typically occur in more open-water, marine habitats (Poulakis and Seitz 2004).

7.2.18.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the U.S. DPS of smalltooth sawfish.

The abundance of smalltooth sawfish in U.S. waters has decreased dramatically over the past century. Efforts are currently underway to provide better estimates of smalltooth sawfish abundance (NMFS 2014b). Current abundance estimates are based on encounter data, genetic sampling, and geographic extent. Carlson and Simpfendorfer (2015) used encounter densities to estimate the female population size to be 600. Chapman et al. (2011) analyzed genetic data from tissue samples (fin clips) to estimate the effective genetic population size as 250 to 350 adults (95 percent confidence interval from 142 to 955). Simpfendorfer (2002) estimated that the U.S. population may number less than five percent of historic levels based on the contraction of the species' range.

The abundance of juveniles encountered in recent studies suggests that the smalltooth sawfish population remains reproductively viable (Poulakis et al. 2014; Seitz and Poulakis 2002;

Simpfendorfer and Wiley 2004). The overall abundance appears to be stable (Wiley and Simpfendorfer 2010). Data analyzed from the Everglades portion of the smalltooth sawfish range suggests that the population growth rate for that region may be around five percent per year (Carlson and Osborne 2012; Carlson et al. 2007). Intrinsic rates of growth for smalltooth sawfish have been estimated at 1.08 to 1.14 per year and 1.237 to 1.150 per year by Simpfendorfer (2000) and Carlson and Simpfendorfer (2015) respectively. However, these intrinsic rates are uncertain due to the lack of long-term abundance data.

Chapman et al. (2011) investigated the genetic diversity within the smalltooth sawfish population. The study reported that the remnant population exhibits high genetic diversity (allelic richness, alleles per locus, heterozygosity) and that inbreeding is rare. The study also suggested that the protected population will likely retain greater than 90 percent of its current genetic diversity over the next century.

Recent capture and encounter data suggest that the current distribution is focused primarily to south and southwest Florida from Charlotte Harbor through the Dry Tortugas (Poulakis and Seitz 2004; Seitz and Poulakis 2002). Water temperatures (no lower than 16° to 18° Celsius) and the availability of appropriate coastal habitat (shallow, euryhaline waters and red mangroves) are the major environmental constraints limiting the distribution of smalltooth sawfish (Bigalow and Schroeder 1953).

7.2.18.3 Vocalization and Hearing

Smalltooth sawfish are elasmobranchs, and although there is no known information on their sound production and hearing abilities, these abilities have been studied in other elasmobranchs species. Elasmobranchs, like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005b; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders, and thus are unable to detect sound pressure (Casper et al. 2012b). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001). Data for elasmobranchs fishes suggest they can detect sound between 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012b; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009a; Ladich and Fay 2013a; Myrberg 2001).

7.2.18.4 Status

The decline in the abundance of smalltooth sawfish has been attributed to fishing (primarily commercial and recreational bycatch), habitat modification (including changes to freshwater flow regimes as a result of climate change), and life history characteristics (i.e., slow-growing, relatively late-maturing, and long-lived species) (NMFS 2009d; Simpfendorfer et al. 2011). These factors continue to threaten the U.S. DPS of smalltooth sawfish. Recent records indicate there is a resident reproducing population of smalltooth sawfish in south and southwest Florida from Charlotte Harbor through the Dry Tortugas, which is also the last U.S. stronghold for the species (Poulakis and Seitz 2004; Seitz and Poulakis 2002; Simpfendorfer and Wiley 2004). This population is likely stable or increasing (Carlson and Osborne 2012; Carlson and Simpfendorfer 2015). While the overall abundance appears to be stable, low intrinsic rates of population increase suggest that the species is particularly vulnerable to rapid population declines (NMFS 2010c).

7.2.18.5 Critical Habitat

Critical habitat for smalltooth sawfish was designated in 2009 and includes two major units: Charlotte Harbor (221,459 acres) and Ten Thousand Islands/Everglades (619,013 acres) (Figure 43). These two units include essential sawfish nursery areas. The locations of nursery areas were determined by analyzing juvenile smalltooth sawfish encounter data in the context of shark nursery criteria (Heupel et al. 2007; Norton et al. 2012). Within the nursery areas, two features were identified as essential to the conservation of the species: red mangroves (*Rhizophora mangle*), and euryhaline habitats with water depths greater than or equal to 0.9 m. The Charlotte Harbor unit includes areas which are moderate to highly developed (Cape Coral, Fort Myers) and includes a highly altered, flow-managed system (Caloosahatchee River). In contrast, the Ten Thousand Island/Everglades unit contains relatively undeveloped, pristine smalltooth sawfish habitat (Poulakis et al. 2014; Poulakis et al. 2011).

7.2.18.6 Recovery Goals

The 2009 Smalltooth Sawfish Recovery Plan (NMFS 2009d) contains complete downlisting/delisting criteria for each of the three following recovery goals:

- Minimize human interactions and associated injury and mortality.
- Protect and/or restore smalltooth sawfish habitats.
- Ensure smalltooth sawfish abundance increases substantially and the species reoccupies areas from which it had been previously extirpated.

7.2.19 Corals

The ESA-listed corals that are likely to be adversely affected by the proposed action face a number of common threats. For this reason, we include a general discussion here on the numerous natural and man-made threats that shape their status and affect their ability to recover. All threats are expected to increase in severity in the future. More detailed information on the threats to listed corals is found in the Final Listing Rule (79 FR 53851; September 10, 2014). Threat information specific to a particular species is then discussed in the corresponding status sections where appropriate.

Several of the most important threats contributing to the extinction risk of corals are related to global climate change. The main concerns regarding impacts of global climate change on coral reefs generally, and on listed corals in particular, are the magnitude and the rapid pace of change in greenhouse gas (GHG) concentrations (e.g., carbon dioxide [CO_2] and methane) and atmospheric warming since the Industrial Revolution in the mid-19th century. These changes are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean (ocean acidification). Ocean acidification affects a number of biological processes in corals, including secretion of their skeletons.

Ocean Warming

Ocean warming is one of the most important threats posing extinction risks to the listed coral species, but individual susceptibility varies among species. The primary observable coral response to ocean warming is bleaching of adult coral colonies, wherein corals expel their symbiotic algae in response to stress. For many corals, an episodic increase of only 1°C–2°C above the normal local seasonal maximum ocean temperature can induce bleaching. Corals can withstand mild to moderate bleaching; however, severe, repeated, and/or prolonged bleaching can lead to colony death. Coral bleaching patterns are complex, with several species exhibiting seasonal cycles in symbiotic algae density. Thermal stress has led to bleaching and mass mortality in many coral species during the past 25 years.

In addition to coral bleaching, other effects of ocean warming can harm virtually every life-history stage in reef-building corals. Impaired fertilization, developmental abnormalities, mortality, impaired settlement success, and impaired calcification of early life phases have all been documented. Average seawater temperatures in reef-building coral habitat in the wider Caribbean have increased during the past few decades and are predicted to continue to rise between now and 2100. Further, the frequency of warm-season temperature extremes (warming events) in reef-building coral habitat has increased during the past 2 decades and is predicted to continue to increase between now and 2100.

Ocean Acidification

Ocean acidification is a result of global climate change caused by increased CO_2 in the atmosphere that results in greater releases of CO_2 that is then absorbed by seawater. Reef-building corals produce skeletons made of the aragonite form of calcium carbonate. Ocean acidification reduces aragonite concentrations in seawater, making it more difficult for corals to build their skeletons. Ocean acidification has the potential to cause substantial reduction in coral calcification and reef cementation. Further, ocean acidification impacts adult growth rates and fecundity, fertilization, pelagic planula settlement, polyp development, and juvenile growth. Ocean acidification can lead to increased colony breakage, fragmentation, and mortality. Based on observations in areas with naturally low pH, the effects of increasing ocean acidification may also include reductions in coral size, cover, diversity, and structural complexity.

As CO_2 concentrations increase in the atmosphere, more CO_2 is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in CO_2 and other GHGs in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans, including in the Caribbean, and is predicted to increase considerably between now and 2100. Along with ocean warming and disease, we consider ocean acidification to be one of the most important threats posing extinction risks to coral species between now and the year 2100, although individual susceptibility varies among the listed corals.

Diseases

Disease adversely affects various coral life history events by, among other processes, causing adult mortality, reducing sexual and asexual reproductive success, and impairing colony growth. A diseased state results from a complex interplay of factors including the cause or agent (e.g., pathogen, environmental toxicant), the host, and the environment. All coral disease impacts are presumed to be attributable to infectious diseases or to poorly-described genetic defects. Coral disease often produces acute tissue loss. Other forms of "disease" in the broader sense, such as temperature-caused bleaching, are discussed in other threat sections (e.g., ocean warming as a result of climate change).

Coral diseases are a common and significant threat affecting most or all coral species and regions to some degree, although the scientific understanding of individual disease causes in corals remains very poor. The incidence of coral disease appears to be expanding geographically, though the prevalence of disease is highly variable between sites and species. Increased prevalence and severity of diseases is correlated with increased water temperatures, which may correspond to increased virulence of pathogens, decreased resistance of hosts, or both. Moreover, the expanding coral disease threat may result from opportunistic pathogens that become damaging only in situations where the host integrity is compromised by physiological stress or immune suppression. Overall, there is mounting evidence that warming temperatures and coral bleaching responses are linked (albeit with mixed correlations) with increased coral disease prevalence and mortality.

Trophic Effects of Reef Fishing

Fishing, particularly overfishing, can have large-scale, long-term ecosystem-level effects that can change ecosystem structure from coral-dominated reefs to algal-dominated reefs ("phase shifts"). Even fishing pressure that does not rise to the level of overfishing potentially can alter trophic interactions that are important in structuring coral reef ecosystems. These trophic interactions include reducing population abundance of herbivorous fish species that control algal growth, limiting the size structure of fish populations, reducing species richness of herbivorous fish, and releasing corallivores from predator control.

In the Caribbean, parrotfishes can graze at rates of more than 150,000 bites per square m per day (Carpenter 1986), and thereby remove up to 90-100 percent of the daily primary production (e.g., algae; Hatcher 1997). With substantial populations of herbivorous fishes, as long as the cover of living coral is high and resistant to mortality from environmental changes, it is very unlikely that the algae will take over and dominate the substrate. However, if herbivorous fish populations, particularly large-bodied parrotfish, are heavily fished and a major mortality of coral colonies occurs, then algae can grow rapidly and prevent the recovery of the coral population. The ecosystem can then collapse into an alternative stable state, a persistent phase shift in which algae replace corals as the dominant reef species. Although algae can have negative effects on adult coral colonies (e.g., overgrowth, bleaching from toxic compounds), the ecosystem-level effects of algae are primarily from inhibited coral recruitment. Filamentous algae can prevent the colonization of the substrate by planula larvae by creating sediment traps that obstruct access to a hard substrate for attachment. Additionally, macroalgae can block successful colonization of the bottom by corals because the macroalgae takes up the available space and causes shading, abrasion, chemical poisoning, and infection with bacterial disease. Trophic effects of fishing are a medium importance threat to the extinction risk for listed corals.

Sedimentation

Human activities in coastal and inland watersheds introduce sediment into the ocean by a variety of mechanisms including river discharge, surface runoff, groundwater seeps, and atmospheric deposition. Humans also introduce sewage into coastal waters through direct discharge, treatment plants, and septic leakage. Elevated sediment levels are generated by poor land use practices and coastal and nearshore construction.

The most common direct effect of sedimentation is sediment's landing on coral surfaces as it settles out from the water column. Corals with certain morphologies (e.g., mounding) can passively reject settling sediments. In addition, corals can actively remove sediment but at a significant energy cost. Corals with large calices (skeletal component that holds the polyp) tend to be better at actively rejecting sediment. Some coral species can tolerate complete burial for several days. Corals that cannot remove sediment will be smothered and die. Sediment can also cause sublethal effects such as reductions in tissue thickness, polyp swelling, zooxanthellae loss, and excess mucus production. In addition, suspended sediment can reduce the amount of light in the water column, making less energy available for coral photosynthesis and growth. Sedimentation also impedes fertilization of spawned gametes and reduces larval settlement and survival of recruits and juveniles.

Nutrient Enrichment

Elevated nutrient concentrations in seawater affect corals through 2 main mechanisms: direct impacts on coral physiology, and indirect effects through stimulation of other community components (e.g., macroalgal turfs and seaweeds, and filter feeders) that compete with corals for space on the reef. Increased nutrients can decrease calcification; however, nutrients may also enhance linear extension while reducing skeletal density. Either condition results in corals that are more prone to breakage or erosion, but individual species do have varying tolerances to increased nutrients. Anthropogenic nutrients mainly come from point-source discharges (such as rivers or sewage outfalls) and surface runoff from modified watersheds. Natural processes, such as *in situ* nitrogen fixation and delivery of nutrient-rich deep water by internal waves and upwelling, also bring nutrients to coral reefs.

7.2.19.1 Elkhorn Coral

Elkhorn coral (*Acropora palmata*) occurs throughout coastal areas in the Caribbean, Gulf of Mexico, and southwestern Atlantic (Figure 44).

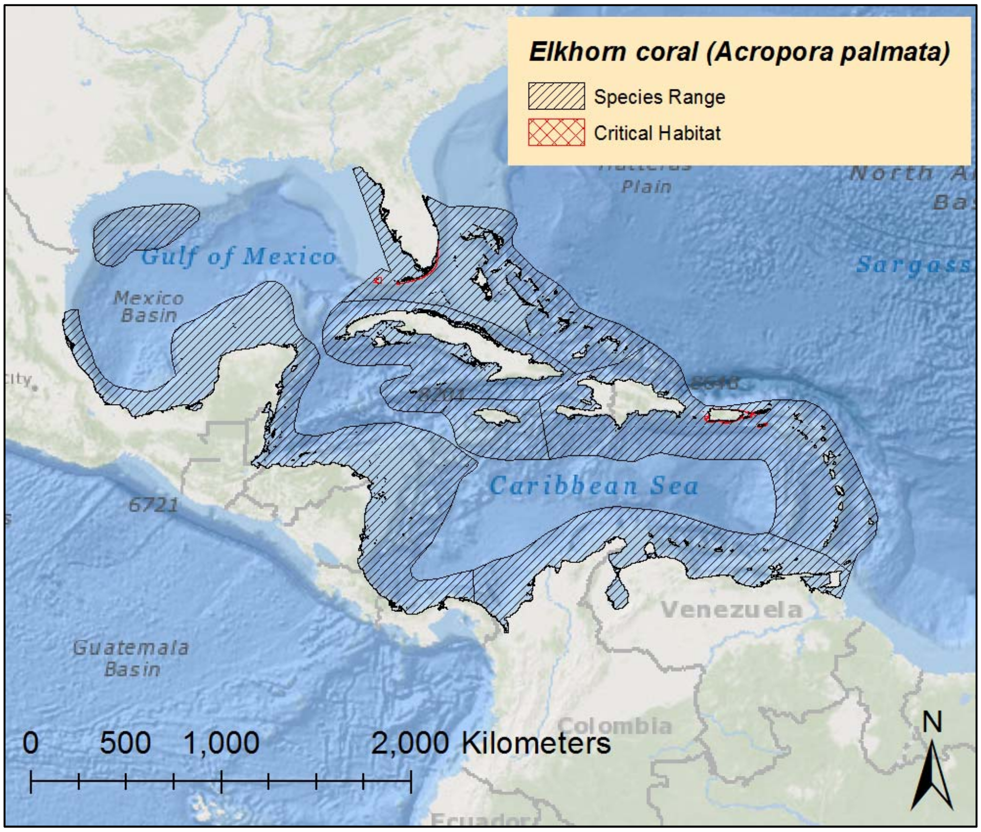


Figure 44. Map showing the range of elkhorn coral.

Elkhorn corals, as with all corals are composed of single polyp body forms, often present in numbers of hundreds to thousands creating dense clusters along the shallow ocean floor called colonies. Polyps are capable of catching and eating their own food, and have their own digestive, nervous, respiratory, and reproductive systems. In addition to being able to catch and eat their own food, elkhorn coral, along with most coral species contain zooxanthellae, a unicellular, symbiotic dinoflagellate, living within the endodermic tissues of individual polyps to provide photosynthetic support to the coral's energy budget and calcium carbonate secretion (Acropora Biological Review Team 2005).

Elkhorn coral was listed as threatened under the ESA in 2006. In 2012, a proposal to change the listing to endangered was made, but in 2014 its threatened status was upheld. In 2008, critical habitat for elkhorn coral was designated in areas surrounding the Florida Keys, Puerto Rico, and portions of the Virgin Islands. Along with staghorn coral, elkhorn coral is the only other large, branching species of coral to produce and occupy vast complex environments within the

Caribbean Sea's reef system. In all, there appears to be two distinct populations of elkhorn coral, a western Caribbean population and an eastern (Baums et al. 2005b) based on genetic analyses.

7.2.19.1.1 Life history

Elkhorn coral, like most stony corals, employ both sexual and asexual reproductive strategies to propagate. Sexual reproduction in corals includes gametogenesis, the process in which cells undergo meiosis to form gametes within the polyps. Since elkhorn coral is hermaphroditic, each polyp contains both sperm and egg cells that are released together in a "bundle", causing the coral gametes to develop externally from the parental colony. Elkhorn coral reproduces sexually after the full moon of July, August, and/or September, depending on location and timing of the full moon (Acropora Biological Review Team 2005). Split spawning (spawning over a 2-month period) has been reported from the Florida Keys (Fogarty et al. 2012). The estimated size at sexual maturity is approximately 250 square inches (1,600 cm^2), and growing edges and encrusting base areas are not fertile (Soong and Lang 1992). Larger colonies have higher fecundity per unit area, as do the upper branch surfaces (Soong and Lang 1992). Although self-fertilization is possible, elkhorn coral is largely self-incompatible (Baums et al. 2005a; Fogarty et al. 2012). Sexual recruitment rates are low, and this species is generally not observed in coral settlement studies in the field. Rates of post-settlement mortality after nine months are high based on settlement experiments (Szmant and Miller 2005).

Reproduction occurs primarily through asexual fragmentation that produces multiple colonies that are genetically identical (Bak and Criens 1982; Highsmith 1982; Lirman 2000; Miller et al. 2007; Wallace 1985). Storms can be a method of producing fragments to establish new colonies (Fong and Lirman 1995). Fragmentation is an important mode of reproduction in many reef-building corals, especially for branching species such as elkhorn coral (Highsmith 1982; Lirman 2000; Wallace 1985).

Because large colonies of elkhorn coral contain several thousand partially autonomous polyps, growth rates for the species are conveyed through the measurement of linear extensions of the organisms' skeletal branches. Depending on the size and location of the colony, physical growth rates for elkhorn corals range from approximately four to eleven cm per year. Branches are up to approximately 50 cm wide and range in thickness of about 4 to 5 cm.

7.2.19.1.2 Population dynamics

The following is a discussion of the species' population and its variance over time. This section consists of abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the elkhorn coral.

Genetic samples from 11 locations throughout the Caribbean indicate that elkhorn coral populations in the eastern Caribbean (St. Vincent and the Grenadines, U.S. Virgin Islands, Curaçao, and Bonaire) have had little or no genetic exchange with populations in the western Atlantic and western Caribbean (Bahamas, Florida, Mexico, Panama, Navassa, and Puerto Rico) (Baums et al. 2005b). While Puerto Rico is more closely connected with the western Caribbean, it is an area of mixing with contributions from both regions (Baums et al. 2005b). Models suggest that the Mona Passage between the Dominican Republic and Puerto Rico promotes dispersion of larval and gene flow between the eastern Caribbean and western Caribbean (Baums et al. 2006b).

Colonial species present a special challenge in determining the appropriate unit to evaluate for abundance. However, the present population of Elkhorn coral is continuing at a very low abundance due to large declines in the past several decades. The western Caribbean is characterized by genetically depauperate populations with lower densities (0.13 ± 0.08 colonies per square meter [m^2]). The eastern Caribbean populations are characterized by denser (0.30 ± 0.21 colonies per m^2), genotypically richer stands (Baums et al. 2006a).

Baums et al. (2006a) concluded that the western Caribbean had higher rates of asexual recruitment and that the eastern Caribbean had higher rates of sexual recruitment. The research team claims that the postulated geographic differences in the contribution of reproductive modes to population structure may be related to habitat characteristics, possibly the amount of shelf area available.

Genotypic diversity is highly variable for elkhorn coral. From the survey data, it can be inferred that genetic variability is more common in colonies within eastern populations as opposed to western. At two sites in the Florida Keys, only one genotype per site was detected out of 20 colonies sampled at each site (Baums et al. 2005b). In contrast, sites within the eastern Caribbean displayed high variability. All 15 colonies sampled in Navassa had unique genotypes (Baums et al. 2006a). Some sites have relatively high genotypic diversity such as in Los Roques, Venezuela (118 unique samples out of 120 samples; Zubillaga et al. 2008) and in Bonaire and Curaçao (Baums et al. 2006a). In the Bahamas, about one third of the sampled colonies were unique genotypes, and in Panama between 24 and 65 percent of the sampled colonies had unique genotypes, depending on the site (Baums et al. 2006a). A more-recent survey conducted along the coast of Puerto Rico found unique genotypes in 75 percent of the samples with high genetic diversity (Mège et al. 2014).

Elkhorn coral occurs in turbulent water on the back reef, fore reef, reef crest, and spur and groove zone in water ranging from one to thirty meters in depth. Historically, elkhorn coral inhabited most waters of the Caribbean between one to five meters depth. This included a diverse set of areas comprising of zones along Puerto Rico, Hispaniola, the Yucatan peninsula, the Bahamas, the southwestern Gulf of Mexico, the Florida Keys, the Southeastern Caribbean islands, and the northern coast of South America. While the present-day spatial distribution of elkhorn coral is similar to its historic spatial distribution, its presence within its range has become increasingly sparse due to declines in the latter half of the 20th century from a variety of abiotic and biotic threats.

Based on population estimates from both the Florida Keys and St. Croix, U.S. Virgin Islands, there are at least hundreds of thousands of elkhorn coral colonies. Absolute abundance is higher than estimates from these two locations given the presence of this species in many other locations throughout its range. The effective population size is smaller than indicated by abundance estimates due to the tendency for asexual reproduction. Across the Caribbean, percent cover appears to have remained relatively stable, albeit it at extremely low levels, since the population crash in the 1980s. Frequency of occurrence has decreased since the 1980s, indicating potential decreases in the extent of occurrence and effects on the species' range. However, the proportions of Caribbean sites where elkhorn coral is present and dominant have recently stabilized since the mid-2000s. There are locations such as the U.S. Virgin Islands where populations of elkhorn coral appear stable or possibly increasing in abundance and some such as the Florida Keys where population number appears to be decreasing.

7.2.19.1.3 Status

The decline in the total abundance of elkhorn coral has been attributed to a series of stressors consisting of disease, temperature-induced bleaching, excessive sedimentation, nitrification, pollution (i.e. oxybenzone from sunscreen), and large hurricanes/tropical storms. It is believed that these effects act synergistically with one another thereby increasing the overall damage to already-stressed elkhorn coral colonies that have undergone disturbance by another threat. The current population trend appears to be steady, although there are places where populations continue to decrease and others where there appears to be modest or contained recovery (Miller et al. 2013b). However, even if growth and recruitment end up surpassing mortality, this species requires prompt analysis and monitoring on a regional scale. Reasoning for this includes the current presence of areas with low genetic diversity and density within western Caribbean populations along with localized high rates of disease and bleaching.

In locations where historic quantitative data are available (Florida, Jamaica, U.S. Virgin Islands), there was a reduction of greater than 97% between the 1970s and early 2000s in elkhorn coral populations (*Acropora* Biological Review Team 2005). Since the 2006 listing of elkhorn coral, continued population declines have occurred in some locations with certain populations of elkhorn coral decreasing up to an additional 50% or more (Colella et al. 2012; Lundgren and Hillis-Starr 2008; Muller et al. 2008; Rogers and Muller 2012a; Williams et al. 2008a). In addition, Williams et al. (2008a) reported asexual recruitment failure between 2004 and 2007 in the upper Florida Keys after a major hurricane season in 2005; less than 5% of the fragments produced recruited into the population. In contrast, several studies describe elkhorn coral populations that are showing some signs of recovery or are stable including in the U.S. Virgin Islands (Grober-Dunsmore et al. 2006a; Mayor et al. 2006a; Rogers and Muller 2012a).

Extrapolated population estimates of elkhorn coral from stratified random samples across habitat types in the Florida Keys were 0.6 ± 0.5 million (standard error [SE]) colonies in 2005, 1.0 ± 0.3 million (SE) colonies in 2007, and 0.5 ± 0.3 million (SE) colonies in 2012. Because these population estimates are based on random sampling, differences between years may be a function of sampling effort rather than an indication of population trends. Relative to the abundance of other corals in the Florida Keys region, elkhorn coral was among the least abundant, ranking among corals that are naturally rare in abundance; historically elkhorn coral was a dominant species on Florida reef. Further, no colonies of elkhorn coral were observed in surveys of the Dry Tortugas in 2006 and 2008. The size class distribution of the Florida Keys population included both small and large individuals (> approximately 103 inches [260 cm), but after 2005 the majority of the colonies were smaller in size. These smallest corals (0-8 inches [0-

20 cm) had approximately 0 to 2 percent partial mortality during all three survey years. Partial mortality across all other size classes was approximately 20-70% in 2005, 5-50% in 2007, and 15-90% in 2012 (Miller et al. 2013b).

Colonies monitored in the upper Florida Keys showed a greater than 50% loss of tissue as well as a decline in the number of colonies, and a decline in the dominance by large colonies between 2004 and 2010 (Vardi et al. 2012) (Williams and Miller 2012). Elasticity analysis from a population model based on data from the Florida Keys has shown that the largest individuals have the greatest contribution to the rate of change in population size (Vardi et al. 2012). Between 2010 and 2013, elkhorn coral in the middle and lower Florida Keys had mixed trends. Population densities remained relatively stable at 2 sites and decreased at 2 sites by 21% and 28% (Lunz 2013).

In terms of density and abundance, maximum elkhorn coral density at ten sites in St. John was 0.18 colonies per m^2 (Muller et al. 2014). Mayor et al. (2006b) surveyed 617 sites in Buck Island Reef National Monument, St. Croix, from May to June 2004 and extrapolated elkhorn coral density observed per habitat type to total available habitat. Within an area of 795 hectares, they estimated 97,232–134,371 (95 percent confidence limits) elkhorn coral colonies with any dimension of connected live tissue greater than one meter. Mean densities (colonies ≥ 1 m) were 0.019 colonies per m^2 in branching coral-dominated habitats and 0.013 colonies per m^2 in other hard bottom habitats.

Puerto Rico contains the greatest known extent of elkhorn coral in the U.S. Caribbean, however, the species is still rarely encountered. Between 2006 and 2007, a survey of 431 random points in habitat suitable for elkhorn coral in 6 marine protected areas in Puerto Rico revealed a variable density of 0-52 elkhorn coral colonies per 100 m^2, with average density of 3.3 colonies per 100 m^2 (0.03 colonies per m^2). Overall 30.7% of all points sampled had live elkhorn coral colonies and total loss of elkhorn coral was evidenced in 13.6% of the random survey areas where only dead standing colonies were present (Schärer et al. 2009).

In stratified random surveys along the south, southeast, southwest, and west coasts of Puerto Rico designed to locate *Acropora* colonies, elkhorn coral was observed at 5 out of 301 stations with sightings outside of the survey area at an additional 2 stations (García Sais et al. 2013). Elkhorn coral colonies were absent from survey sites along the southeast coast. Maximum density was 1.2 colonies per m^2, and maximum colony size was approximately 7.5 ft (2.3 m) in diameter (García Sais et al. 2013).

At 8 of 11 sites in St. John, colonies of elkhorn coral increased in abundance, between 2001 and 2003, particularly in the smallest size class, with the number of colonies in the largest size class decreasing (Grober-Dunsmore et al. 2006b). Colonies of elkhorn coral monitored monthly between 2003 and 2009 in Haulover Bay on St. John, U.S. Virgin Islands suffered bleaching and mortality from disease but showed an increase in abundance and size at the end of the monitoring period (Rogers and Muller 2012b). The overall density of elkhorn coral colonies around St. John did not significantly differ between 2004 and 2010 with 6 out of the 10 sites showing an increase in colony density. Size frequency distribution did not significantly change at 7 of the 10 sites, with 2 sites showing an increased abundance of large-sized (> 51 cm) colonies (Muller et al. 2014). However, the 2017 hurricanes have affected likely several areas where elkhorn coral colony abundance was stable or increasing given the magnitude of the two hurricanes that severely impacted the Caribbean.

7.2.19.1.4 Critical Habitat

Critical habitat units for elkhorn and staghorn coral were designated in 2008 and include Florida (portions of Southeastern Florida and the Florida Keys), Puerto Rico, St. Thomas/St. John, and St. Croix. The Florida unit comprises approximately 1,329 square miles of marine habitat; Puerto Rico approximately 1,383 square miles; St. Thomas/St. John approximately 121 square miles; and St. Croix approximately 126 square miles. Thus, the total area covered by the designation is approximately 2,959 square miles. Within the geographic area occupied by a listed species, critical habitat consists of specific areas on which are found those physical or biological features essential to the conservation of the species. The feature essential to the conservation of acroporid corals is substrate of suitable quality and availability in water depths from the mean high-water line to 30 m to allow for successful sexual and asexual reproduction. Successful sexual and asexual reproduction includes flourishing larval settlement, recruitment, and reattachment of coral fragments (73 FR 72210). "Substrate of suitable quality and availability" means consolidated hard bottom or dead coral skeletons free from fleshy macroalgae or turf algae and sediment cover.

7.2.19.1.5 Recovery Goals

The 2015 Elkhorn Coral (*Acropora palmata*) and Staghorn Coral (*A. cervicornis*) Recovery Plan contains complete downlisting/delisting criteria for each of the two following recovery goals:

- Ensure population viability
  - Specific criteria include: 1) Preserving Abundance; 2) Maintaining Genotypic Diversity; and 3) Properly Observing and Recording Recruitment Rates
- Eliminate or sufficiently abate global, regional, and local threats
  - Specific criteria include: 1) Developing quantitative recovery criterion through research to identify, treat, and reduce outbreaks of coral disease; 2) Controlling the Local and Global Impacts of Rising Ocean Temperature and Acidification; 3) Reducing the Loss of Recruitment Habitat (if criterion 1, preserving abundance, is met then this objective is complete; 4) Reducing sources of nutrients, sediments, and contaminants; 5) Developing and adopting appropriate and effective regulatory mechanisms to abate threats; 6) Reducing impacts of natural and anthropogenic abrasion and breakage; and 7) Reducing impacts of predation.

7.2.19.2 Staghorn Coral

Staghorn coral (*Acropora cervicornis*) has the same range as elkhorn coral, occurring throughout coastal areas in the Caribbean, Gulf of Mexico, and southwestern Atlantic (Figure 44).

Staghorn coral is characterized by antler-like colonies with straight or slightly curved, cylindrical branches. The diameter of branches ranges form 0.25 – 5 cm (Lirman et al. 2010), and linear branch growth rates have been reported to range between 3 – 11.5 cm per year (*Acropora* Biological Review Team 2005). The species can exist as isolated branches, individual colonies up to about 1.5 m diameter, and thickets comprised of multiple colonies that are difficult to distinguish from one another (*Acropora* Biological Review Team 2005).

Staghorn coral naturally occurs on spur and groove, bank reef, patch reef, and transitional reef habitats, as well as on limestone ridges, terraces, and hard bottom habitats (Cairns 1982b; Davis 1982; Gilmore and Hall 1976; Goldberg 1973; Jaap 1984; Miller et al. 2008; Wheaton and Jaap 1988). Historically it grew in thickets in water ranging from approximately 5 – 20 m in depth; though it has rarely been found to approximately 60 m (Davis 1982; Jaap 1984; Jaap et al. 1989; Schuhmacher and Zibrowius 1985; Wheaton and Jaap 1988). At the northern extent of its range, it grows in deeper water, 16-30 m (Goldberg 1973). Historically, staghorn coral was one of the primary constructors of mid-depth 10-15 m reef terraces in the western Caribbean, including Jamaica, the Cayman Islands, Belize, and some reefs along the eastern Yucatan peninsula (Adey 1978). In the Florida Keys, staghorn coral occurs in various habitats but is most prevalent on patch reefs as opposed to their former abundance in deeper fore-reef habitats (Miller et al. 2008). There is no evidence of range constriction, though loss of staghorn coral at the reef level has occurred (*Acropora* Biological Review Team 2005).

Precht and Aronson (2004) suggest that coincident with climate warming, staghorn coral recently re-occupied its historic range after contracting to south of Miami, Florida, during the late Holocene. They based this idea on the presence of large thickets off Ft. Lauderdale, Florida, which were discovered in 1998 and had not been reported in the 1970s or 1980s (Precht 2004). However, because the presence of sparse staghorn coral colonies in Palm Beach County, north of Ft. Lauderdale, was reported in the early 1970s (though no thicket formation was reported; Goldberg 1973), there is uncertainty associated with whether these thickets were present prior to their discovery or if they recently appeared coincident with warming. The proportion of reefs with staghorn coral present decreased dramatically after the Caribbean-wide mass mortality in the 1970s and 1980s, indicating the spatial structure of the species has been affected by extirpation from many localized areas throughout its range (Jackson et al. 2014).

7.2.19.2.1 Life history

Relative to other corals, staghorn coral has a high growth rate that has allowed acroporid reef growth to keep pace with past changes in sea level (Fairbanks 1989). Growth rates, measured as skeletal extension of the end of branches, range from approximately four to eleven cm per year (*Acropora* Biological Review Team 2005). Annual linear extension has been found to be dependent on the size of the colony. New recruits and juveniles typically grow at slower rates. Stressed colonies and fragments may also exhibit slower growth.

Staghorn coral is a hermaphroditic broadcast spawning species. The spawning season occurs several nights after the full moon in July, August, or September depending on location and timing of the full moon and may be split over the course of more than one lunar cycle (Szmant 1986; Vargas-Angel et al. 2006). The estimated size at sexual maturity is approximately seventeen cm branch length, and large colonies produce proportionally more gametes than small colonies (Soong and Lang 1992). Basal and branch tip tissue is not fertile (Soong and Lang 1992). Sexual recruitment rates are low, and this species is generally not observed in coral settlement studies. Laboratory studies have found that certain species of crustose-coralline algae produce exudates that facilitate larval settlement and post-settlement survival (Ritson-Williams et al. 2010).

Reproduction occurs primarily through asexual fragmentation that produces multiple colonies that are genetically identical (Tunnicliffe 1981). The combination of branching morphology, asexual fragmentation, and fast growth rates, relative to other corals, can lead to persistence of large areas dominated by staghorn coral. The combination of rapid skeletal growth rates and frequent asexual reproduction by fragmentation can enable effective competition and can facilitate potential recovery from disturbances when environmental conditions permit. However, low sexual reproduction can lead to reduced genetic diversity and limits the capacity to repopulate spatially dispersed sites.

7.2.19.2.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section consists of abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the staghorn coral.

Miller et al. (2013b) extrapolated population abundance of staghorn coral in the Florida Keys and Dry Tortugas from stratified random samples across habitat types. Population estimates of staghorn coral in the Florida Keys were 10.2 ± 4.6 (SE) million colonies in 2005, 6.9 ± 2.4 (SE) million colonies in 2007 and 10.0 ± 3.1 (SE) million colonies in 2012. Population estimates in the Dry Tortugas were 0.4 ± 0.4 (SE) million colonies in 2006 and 3.5 ± 2.9 (SE) million colonies in 2008, though the authors note their sampling scheme in the Dry Tortugas was not optimized for staghorn coral. Because these population estimates were based on random sampling, differences in abundance estimates between years is more likely to be a function of sample design rather than population trends. In both the Florida Keys and Dry Tortugas, most of the population was dominated by small colonies less than 12-inch (30 cm) diameter. Further, partial mortality was reported as highest in 2005 with up to 80 percent mortality observed and lowest in 2007 with a maximum of 30 percent. In 2012, partial mortality ranged from 20-50 percent across most size classes.

Staghorn coral historically was one of the dominant species on most Caribbean reefs, forming large, single-species thickets and giving rise to the nominal distinct zone in classical descriptions of Caribbean reef morphology (Goreau 1959). Massive, Caribbean-wide mortality, apparently primarily from white band disease (Aronson and Precht 2001), spread throughout the Caribbean in the mid-1970s to mid-1980s and precipitated widespread and radical changes in reef community structure (Brainard et al. 2011a). In addition, continuing coral mortality from periodic acute events such as hurricanes, disease outbreaks, and mass bleaching events has added to the decline of staghorn coral (Brainard et al. 2011a). In locations where quantitative data are available (Florida, Jamaica, U.S. Virgin Islands, Belize), there was a reduction of approximately 92 to greater than 97% between the 1970s and early 2000s (Acropora Biological Review Team 2005).

Since the 2006 listing of staghorn coral as threatened, continued population declines have occurred in some locations with certain populations of both listed *Acropora* species decreasing up to an additional 50% or more (Colella et al. 2012; Lundgren and Hillis-Starr 2008; Muller et al. 2008; Rogers and Muller 2012a; Williams et al. 2008a). There are some small pockets of remnant robust populations such as in southeast Florida (Vargas-Angel et al. 2003), Honduras (Keck et al. 2005; Riegl et al. 2009), and Dominican Republic (Lirman et al. 2010). Additionally, Lidz and Zawada (2013) observed 400 colonies of staghorn coral along 44 miles (70.2 km) of transects near Pulaski Shoal in the Dry Tortugas where the species had not been seen since the cold water die-off of the 1970s. Cover of staghorn coral increased on a Jamaican reef from 0.6% in 1995 to 10.5% in 2004 (Idjadi et al. 2006).

Riegl et al. (2009) monitored staghorn coral in photo plots on the fringing reef near Roatan, Honduras from 1996 to 2005. Staghorn coral cover declined from 0.42 percent in 1996 to 0.14 percent in 1999 after the Caribbean bleaching event in 1998 and mortality from run-off associated with a Category 5 hurricane. Staghorn coral cover further declined to 0.09 percent in 2005. Staghorn coral colony frequency decreased 71 percent between 1997 and 1999. In sharp contrast, offshore bank reefs near Roatan had dense thickets of staghorn coral with 31 percent cover in photo-quadrats in 2005 and appeared to survive the 1998 bleaching event and hurricane, most likely due to bathymetric separation from land and greater flushing. Modeling showed that under undisturbed conditions, retention of the dense staghorn coral stands on the banks off Roatan is likely with a possible increased shift towards dominance by other coral species. However, the authors note that because their data and the literature seem to point to extrinsic factors as driving the decline of staghorn coral, it is unclear what the future may hold for this dense population (Riegl et al. 2009).

While cover of staghorn coral increased from 0.6 percent in 1995 to 10.5 percent in 2004 (Idjadi et al. 2006) and 44 percent in 2005 on a Jamaican reef, it collapsed after the 2005 bleaching event and subsequent disease to less than 0.5 percent in 2006 (Quinn and Kojis 2008). A cold water die-off across the lower to upper Florida Keys in January 2010 resulted in the complete mortality of all staghorn coral colonies at 45 of the 74 reefs surveyed (61 percent) (Schopmeyer et al. 2012). Walker et al. (2012) report increasing size of 2 thickets (expansion of up to 7.5 times the original size of 1 of the thickets) monitored off southeast Florida, but also noted that cover within monitored plots concurrently decreased by about 50 percent highlighting the dynamic nature of staghorn coral distribution via fragmentation and re-attachment.

A report on the status and trends of Caribbean corals over the last century indicates that cover of staghorn coral has remained relatively stable (though much reduced) throughout the region since the large mortality events of the 1970s and 1980s. The frequency of reefs at which staghorn coral was described as the dominant coral has remained stable. The number of reefs with staghorn coral present declined during the 1980s (from approximately 50 to 30 percent of reefs), remained relatively stable at 30 percent through the 1990s, and decreased to approximately 20 percent of the reefs in 2000-2004 and approximately 10 percent in 2005-2011 (Jackson et al. 2014).

Vollmer and Palumbi (2007) examined 22 populations of staghorn coral from 9 regions in the Caribbean (Panama, Belize, Mexico, Florida, Bahamas, Turks and Caicos, Jamaica, Puerto Rico, and Curaçao) and concluded that populations greater than approximately 500 km apart are genetically different from each other with low gene flow across the greater Caribbean. Fine-scale genetic differences have been detected at reefs separated by as little as two kilometers, suggesting that gene flow in staghorn coral may not occur at much smaller spatial scales (Garcia Reyes and Schizas 2010; Vollmer and Palumbi 2007). This fine-scale population structure was greater when considering genes of elkhorn coral were found in staghorn coral due to back-crossing of the hybrid *A. prolifera* with staghorn coral (Garcia Reyes and Schizas 2010; Vollmer and Palumbi 2007). Populations in Florida and Honduras are genetically distinct from each other and other populations in the U.S. Virgin Islands, Puerto Rico, Bahamas, and Navassa (Baums et al. 2010), indicating little to no larval connectivity overall. However, some potential connectivity between the U.S. Virgin Islands and Puerto Rico was detected and also between Navassa and the Bahamas (Baums et al. 2010).

Staghorn coral is distributed throughout the Caribbean Sea, in the southwestern Gulf of Mexico, and in the western Atlantic Ocean. The fossil record indicates that during the Holocene epoch, staghorn coral was present as far north as Palm Beach County in southeast Florida (Lighty et al. 1978), which is also the northern extent of its current distribution (Goldberg 1973). Staghorn coral commonly occurs in water ranging from 5-20 m in depth, though it occurs in depths of 16-30 m at the northern extent of its range and has been rarely found to 60 m in depth.

Based on population estimates, there are at least tens of millions of colonies present in the Florida Keys and Dry Tortugas combined. Absolute abundance is higher than the estimate from these two locations given the presence of this species in many other locations throughout its range. The effective population size is smaller than indicated by abundance estimates due to the tendency for asexual reproduction. There is no evidence of range constriction or extirpation at the island level. However, the species is absent at the reef level. Populations appear to consist mostly of isolated colonies or small groups of colonies compared to the vast thickets once prominent throughout its range. Thickets are a prominent feature at only a few known locations. Across the Caribbean, percent cover appears to have remained relatively stable since the population crash in the 1980s. Frequency of occurrence has decreased since the 1980s. There are examples of increasing trends in some locations (Dry Tortugas and southeast Florida), but not over larger spatial scales or longer periods. Population model projections from Honduras at one of the only known remaining thickets indicate the retention of this dense stand under undisturbed conditions. If refuge populations are able to persist, it is unclear whether they would be able to repopulate nearby reefs as observed sexual recruitment is low. Thus, we conclude that the species has undergone substantial population decline and decreases in the extent of occurrence throughout its range. Percent benthic cover and proportion of reefs where staghorn coral is dominant have remained stable since the mid-1980s and since the listing of the species as threatened in 2006. We also conclude that population abundance is at least tens of millions of colonies, but likely to decrease in the future with increasing threats.

7.2.19.2.3 Status

The species has undergone substantial population decline and decreases in the extent of occurrence throughout its range due mostly to disease. Although localized mortality events have continued to occur, percent benthic cover and proportion of reefs where staghorn coral is dominant have remained stable over its range since the mid-1980s. There is evidence of synergistic effects of threats for this species where the effects of increased nutrients are combined with acidification and sedimentation. Staghorn coral is highly susceptible to a number of threats, and cumulative effects of multiple threats are likely to exacerbate vulnerability to extinction. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because staghorn coral is limited to areas with high, localized human impacts and predicted increasing threats. Staghorn coral commonly occurs in water ranging from 5-20 m in depth, though it occurs in depths of 16-30 m at the northern extent of its range, and has been rarely found to 60 m in depth. It occurs in spur and groove, bank reef, patch reef, and transitional reef habitats, as well as on limestone ridges, terraces, and hard bottom habitats. This habitat heterogeneity moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef and hard bottom environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute population abundance has been estimated as at least tens of millions of colonies in the Florida Keys and Dry Tortugas combined and is higher than the estimate from these two locations due to the occurrence of the species in many other areas throughout its range. Staghorn coral has low sexual recruitment rates, which exacerbates vulnerability to extinction due to decreased ability to recover from mortality events when all colonies at a site are extirpated. In contrast, its fast growth rates and propensity for formation of clones through asexual fragmentation enables it to expand between rare events of sexual recruitment and increases its potential for local recovery from mortality events, thus moderating vulnerability to extinction. Its abundance and life history characteristics, combined with spatial variability in ocean warming and acidification across the species' range, moderate the species' vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, we also anticipate that the population abundance is likely to decrease in the future with increasing threats.

Since the 2006 listing of staghorn coral as threatened, continued population declines have occurred in some locations with certain populations of both listed *Acropora* species decreasing up to an additional 50% or more (Colella et al. 2012; Lundgren and Hillis-Starr 2008; Muller et al. 2008; Rogers and Muller 2012a; Williams et al. 2008a). There were some small pockets of remnant robust populations such as in southeast Florida (Vargas-Angel et al. 2003), but these may have been impacted since the surveys reported them were completed, particularly by the mass bleaching event in 2005 and the 2017 hurricanes. Additionally, Lidz and Zawada (2013) observed 400 colonies of staghorn coral along 44 miles (70.2 km) of transects near Pulaski Shoal in the Dry Tortugas where the species had not been seen since the cold water die-off of the 1970s.

Miller et al. (2013b) extrapolated population abundance of staghorn coral in the Florida Keys and Dry Tortugas from stratified random samples across habitat types. Population estimates of staghorn coral in the Florida Keys were 10.2 ± 4.6 (SE) million colonies in 2005, 6.9 ± 2.4 (SE) million colonies in 2007, and 10.0 ± 3.1 (SE) million colonies in 2012. Population estimates in the Dry Tortugas were 0.4 ± 0.4 (SE) million colonies in 2006 and 3.5 ± 2.9 (SE) million colonies in 2008, though the authors note their sampling scheme in the Dry Tortugas was not optimized for staghorn coral. Because these population estimates were based on random sampling, differences in abundance estimates between years is more likely to be a function of sample design rather than population trends. In both the Florida Keys and Dry Tortugas, most of the population was dominated by small colonies less than 12 in (30 cm) diameter. Further, partial mortality was reported as highest in 2005 with up to 80% mortality observed and lowest in 2007 with a maximum of 30%. In 2012, partial mortality ranged from 20-50% across most size classes. A cold water die-off across the lower to upper Florida Keys in January 2010 resulted in the complete mortality of all staghorn coral colonies at 45 of the 74 reefs surveyed (61%; (Schopmeyer et al. 2012). Walker et al. (2012) report increasing size of 2 thickets (expansion of up to 7.5 times the original size of 1 of the thickets) monitored off southeast Florida, but also noted that cover within monitored plots concurrently decreased by about 50% highlighting the dynamic nature of staghorn coral distribution via fragmentation and re-attachment.

Staghorn coral was observed in 21 out of 301 stations between 2011 and 2013 in stratified random surveys designed to detect *Acropora* colonies along the south, southeast, southwest, and west coasts of Puerto Rico (García Sais et al. 2013). Staghorn coral was also observed at 16 sites outside of the surveyed area. The largest colony was 24 inches (60 cm) and density ranged from 1-10 colonies per 162 ft^2 (15 m^2; García Sais et al. 2013).

Staghorn corals have been reported on inshore colonized hard bottom, mid-shelf colonized hard bottom and coral reefs, and offshore shelf reefs around the U.S. Virgin Islands, although numbers of colonies have largely not been quantified except in cases of proposed water resources development projects. The National Coral Reef Monitoring Program (NCRMP), which began in 2012 and is administered by NOAA's Coral Reef Conservation Program, has now completed 2 surveys in the U.S. Virgin Islands. Based on the data, staghorn coral colonies have been observed at various locations around all three of the main islands (St. Thomas, St. John, and St. Croix) in 2013 and 2015 and in waters around Buck Island, St. Croix and Cane Bay, St. Croix in 2012 when the first NCRMP survey was conducted in these two locations only in St. Croix. The surveys are based on stratified random sampling in coral habitat types (colonized hard bottom, coral reef) in water depths less than 100 ft. This means that the same locations are not necessarily visited during each biannual sampling event as sampling locations are selected randomly so there are likely to be more colonies of these corals than found in the surveys. Staghorn coral colonies were observed more frequently around St. Thomas than St. John or St. Croix during the 2013 and 2015 NCRMP surveys but this does not necessarily indicate the species is more prevalent in St. Thomas in comparison to other areas in the U.S. Virgin Islands.

7.2.19.2.4 Critical Habitat

Elkhorn and staghorn coral critical habitat is described further in Section 7.2.19.1.4.

7.2.19.2.5 Recovery Goals

The recovery goals for elkhorn and staghorn corals were described in the 2015 Elkhorn Coral (*Acropora palmata*) and Staghorn Coral (*A. cervicornis*) Recovery Plan and detailed in Section 7.2.19.1.5 (Elkhorn Coral). Two recovery goals were identified for Atlantic acroporid corals:

- Ensure population viability
- Eliminate or sufficiently abate global, regional, and local threats.

7.2.19.3 Pillar Coral

Pillar coral (*Dendrogyra cylindrus*) is present in the western Atlantic Ocean and throughout the greater Caribbean Sea, though absent from the southwest Gulf of Mexico (Tunnell 1988; Figure 45).

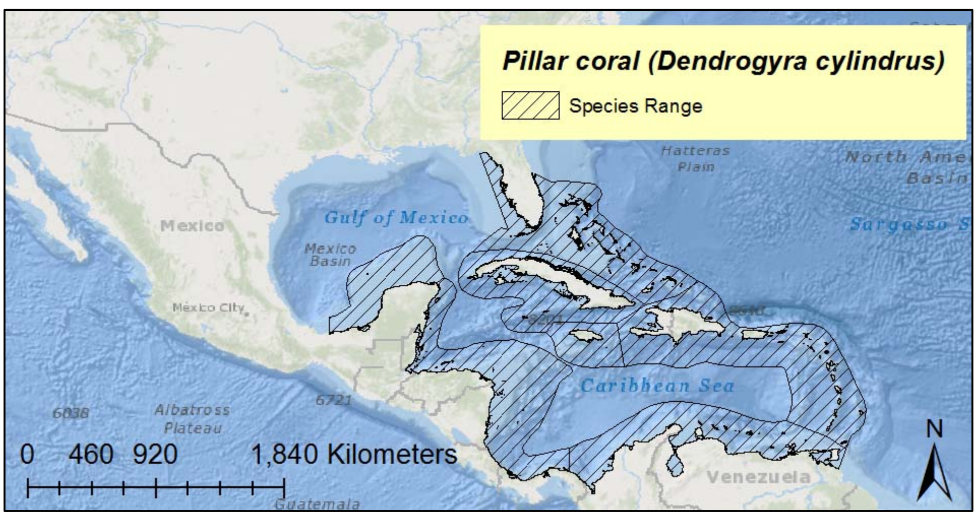


Figure 45. Range map for pillar coral.

On September 10, 2014, NMFS listed pillar star coral as threatened (79 FR 53851). Pillar corals form tubular columns on top of encrusted foundations. Colonies are generally grey-brown in color and may reach approximately three meters in height. Polyps' tentacles remain extended during the day, giving columns a furry appearance. Pillar coral inhabits most reef environments in water depths ranging from approximately one to twenty-five meters, but it is most common in water between approximately five to fifteen meters deep (Acosta and Acevedo 2006; Cairns 1982a; Goreau and Wells 1967).

7.2.19.3.1 Life history

Reported average growth rates for pillar coral have been documented to be approximately 1.8-2.0 cm per year in linear extension within the Florida Keys, compared to 0.8 cm per year as reported in Colombia and Curaçao. Partial mortality rates are size-specific with larger colonies having greater rates. Frequency of partial mortality can be high (e.g., 65 percent of 185 colonies surveyed in Colombia), while the amount of partial mortality per colony is generally low (average of three percent of tissue area affected per colony).

Pillar coral is a gonochoric broadcast spawning species with relatively low annual egg production for its size. The combination of gonochoric spawning with persistently low population densities is expected to yield low rates of successful fertilization and low larval supply. Sexual recruitment of this species is low, and reports indicate juvenile colonies are lacking in the Caribbean. Spawning has been observed to occur several nights after the full moon of August in the Florida Keys (Neely et al. 2013; Waddell and Clarke 2008b) and in La Parguera, Puerto Rico (Szmant 1986). Pillar coral can also reproduce asexually by fragmentation following storms or other physical disturbance, but it is uncertain how much storm-generated fragmentation contributes to asexually produced offspring.

7.2.19.3.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section consists of abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the pillar coral.

Pillar coral is uncommon but conspicuous with scattered, isolated colonies and is rarely found in aggregations. Benthic cover is generally less than one percent in monitoring studies. Mean density of pillar coral was approximately 0.5 colonies per 10 m^2 in the Florida Keys between 2005 and 2007. Density of pillar corals in the Caribbean is also low and on average less than 0.1 colonies per 10 m^2. The average number of pillar coral colonies in remote reefs off southwest Cuba was 0.013 ± 0.045 colonies per 10 m (approximately 32 ft) transect, and the species ranked sixth rarest out of 38 coral species (Alcolado et al. 2010b). In a study of pillar coral demographics at Providencia Island, Colombia, a total of 283 pillar coral colonies were detected in a survey of 1.66 km^2 (0.6 square miles) for an overall density of approximately 0.000017 colonies per 10 m^2 (Acosta and Acevedo 2006).

Benthic cover is generally less than 1 percent in monitoring studies. Pillar coral's average cover was 0.002 percent on patch reefs and 0.303 percent in shallow offshore reefs in annual surveys of 37 sites in the Florida Keys between 1996 and 2003 (Somerfield et al. 2008). In surveys conducted in Florida between 1996 and 2016, cover of pillar coral ranged from 0 to 0.5 percent with an average of 0.0002 percent (NOAA NCRMP). In Puerto Rico, cover of pillar coral ranged between 0 and 4 percent with an average of 0.02 percent in surveys conducted between 2001 and 2016 (NOAA NCRMP). In Dominica, pillar coral comprised less than 0.9 percent cover and was present at 13.3 percent of 31 surveyed sites (Steiner 2003b). Pillar coral was observed on 1 of 7 fringing reefs surveyed off Barbados, and cover was 2.7 ± 1.4 percent (Tomascik and Sander 1987).

Other than the declining population in Florida, there are two reports of population trends from the Caribbean. In monitored photo-stations in Roatan, Honduras, cover of pillar coral increased slightly from 1.35 percent in 1996 to 1.67 percent in 1999 and then declined to 0.44 percent in 2003 and to 0.43 percent in 2005 (Riegl et al. 2009).

Pillar coral is currently uncommon to rare throughout Florida and the Caribbean. Low abundance and infrequent encounter rate in monitoring programs result in small samples sizes. The low coral cover of this species renders monitoring data difficult to extrapolate to realize trends. The few studies that report pillar coral population trends indicate a general decline at some specific sites, though it is likely that the population remains stable at other sites. Low density and gonochoric broadcast spawning reproductive mode, coupled with no observed sexual recruitment, indicate that natural recovery potential from mortality is low.

7.2.19.3.3 Status

Pillar coral survival is susceptible to a number of threats, but there is little evidence of population declines thus far. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because pillar coral is limited to an area with high, localized human impacts and predicted increasing threats. Pillar coral inhabits most reef environments in water depths ranging from one to twenty-five meters, but is naturally rare. Estimates of absolute abundance are at least tens of thousands of colonies in the Florida Keys, and absolute abundance is higher than estimates from this location due to the occurrence of the species in many other areas throughout its range. It is a gonochoric broadcast spawner with observed low sexual recruitment. Its low abundance, combined with its geographic location, exacerbates vulnerability to extinction. This is because increasingly severe conditions within the species' range are likely to affect a high proportion of its population at any given point in time. Also, low sexual recruitment is likely to inhibit recovery potential from mortality events, further exacerbating its vulnerability to extinction. We anticipate that pillar coral is likely to decrease in abundance in the future with increasing threats.

Information on pillar coral is most extensive for Florida. Pillar coral ranked as the least abundant to third least abundant coral species in stratified random surveys of the Florida Keys between 2005 and 2009 and was not encountered in surveys in 2012 (Miller et al. 2013c). Pillar coral was seen only on the ridge complex and mid-channel reefs at densities of approximately 1 and 0.1 colonies per 10 m^2, respectively, between 2005 and 2010 in surveys from West Palm Beach to the Dry Tortugas (Burman et al. 2012). In surveys conducted between 1999 and 2016 from Palm Beach to the Dry Tortugas, pillar coral was present at 2% of sites surveyed and ranged in density from 0 to 0.4 colonies per m^2 with an average density of 0.004 colonies per 10 m^2 (NOAA, unpublished data). In 2014, there were 714 known colonies of pillar coral along the Florida reef tract from southeast Florida to the Dry Tortugas. By 2017, many of these colonies had suffered tissue loss, and over half (57%) suffered complete mortality due to disease, most likely associated with multiple years of warmer than normal temperatures (K. Neely and C. Lewis, unpublished data). The majority of these colonies were lost from the northern portion of the reef tract (Figure 46).

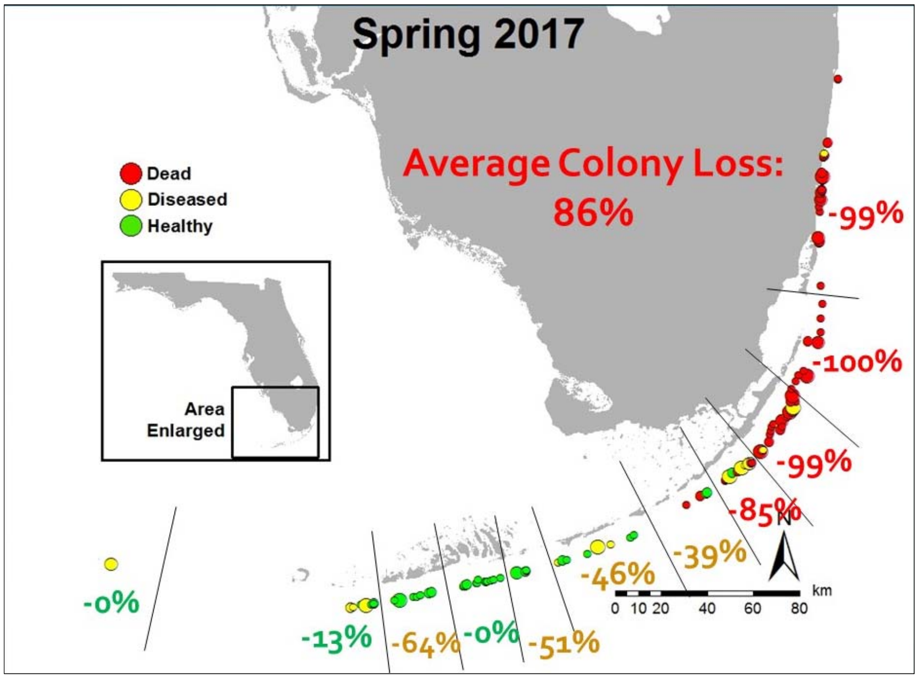


Figure 46. Condition of known pillar coral colonies in Florida between 2014 and 2017 (Figure courtesy of K. Neely and C. Lewis).

In surveys conducted in the U.S. Virgin Islands between 1992 and 2015, percent cover of pillar coral ranged from 0 to 6 percent with an average cover of 0.03 percent (NOAA, unpublished data). In the U.S. Virgin Islands, 7 percent of 26 monitored colonies in permanent monitoring sites experienced total colony mortality between 2005 and 2007, though the very low cover of pillar coral (0.04 percent) remained relatively stable during this time period (Smith et al. 2013). Density of pillar coral ranged between 0 and 0.3 colonies per m^2 with an average density of 0.01 colonies per 10 m^2; it occurred in 3 percent of the randomly selected sites surveyed by NOAA between 2002 and 2015 (NOAA, unpublished data). At permanent monitoring stations in the U.S. Virgin Islands, pillar coral was observed in low abundance at 10 of 33 sites and ranged in cover from less than 0.05-0.22 percent where present (Smith 2013). In Puerto Rico, density of pillar coral ranged from 0 to 0.3 colonies per m^2 with an average density of 0.03 colonies per 10 m^2; it occurred at 4 percent of the sites surveyed between 2008 and 2016 (NOAA, unpublished data).

7.2.19.3.4 Critical Habitat

No critical habitat has been designated for pillar coral.

7.2.19.3.5 Recovery Goals

No final recovery plans currently exists for pillar coral, however a recovery outline was published in 2015. The following short and long-term recovery goals are listed in the document:

Short Term Goals:

- Increase understanding of population dynamics, population distribution, abundance, trends, and structure through research, monitoring, and modeling
- Through research, increase understanding of genetic and environmental factors that lead to variability of bleaching and disease susceptibility
- Decrease locally manageable stress and mortality sources (e.g., acute sedimentation, nutrients, contaminants, and over-fishing).
- Prioritize implementation of actions in the recovery plan for elkhorn and staghorn corals that will benefit *D. cylindrus*, *M. ferox*, and *Orbicella* spp.

Long Term Goals:

- Cultivate and implement U.S. and international measures to reduce atmospheric carbon dioxide concentrations to curb warming and acidification impacts and possibly disease threats.
- Implement ecosystem-level actions to improve habitat quality and restore keystone species and functional processes to maintain adult colonies and promote successful natural recruitment.

7.2.19.4 Rough Cactus Coral

Rough cactus coral (*Mycetophyllia ferox*) occurs in the western Atlantic Ocean and throughout the wider Caribbean Sea (Figure 47).

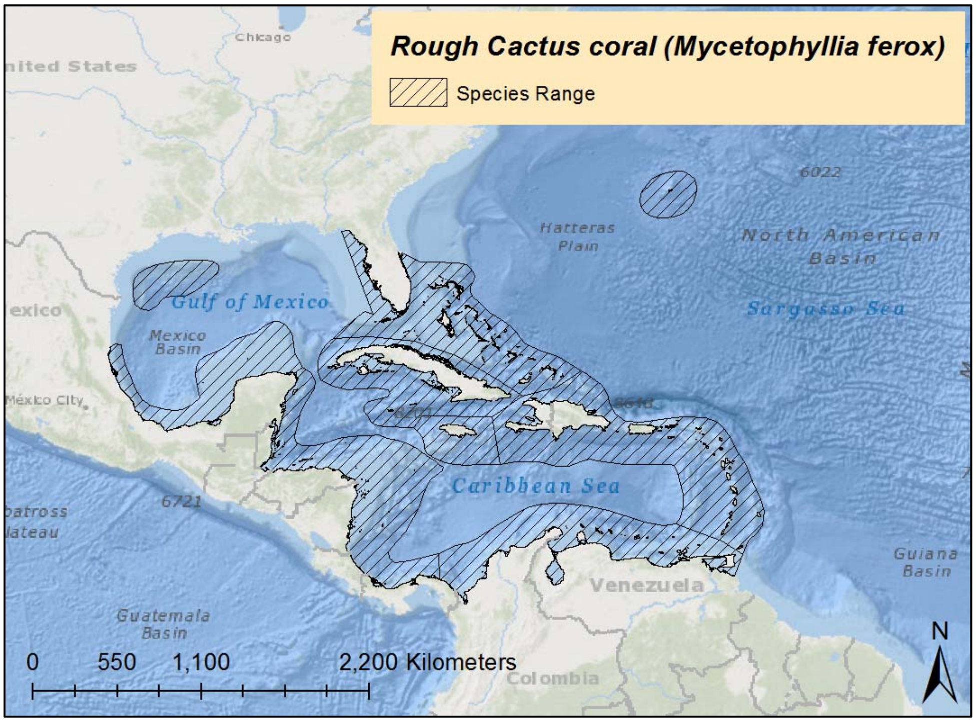


Figure 47. Range map for rough cactus coral.

Rough cactus coral forms a thin, encrusting plate that is weakly attached to substrate. Rough cactus coral is taxonomically distinct (i.e., separate species), though difficult to distinguish in the field from other *Mycetophyllia* species.

While rough cactus coral occurs in the western Atlantic Ocean and throughout the wider Caribbean Sea, it has not been reported in the Flower Garden Banks (Gulf of Mexico) or in Bermuda. It inhabits reef environments in water depths of five to ninety meters, including shallow and mesophotic habitats (e.g., > 30 m).

7.2.19.4.1 Life history

Rough cactus coral is a hermaphroditic brooding species. Colony size at first reproduction is greater than 100 cm^2. Recruitment of rough cactus coral appears to be very low, even in studies from the 1970s. Rough cactus coral has a lower fecundity compared to other species in its genus (Morales Tirado 2006). Over a ten-year period, no colonies of rough cactus coral were observed to recruit to an anchor-damaged site in the U.S. Virgin Islands, although adults were observed on the adjacent reef (Rogers and Garrison 2001). No other life history information appears to exist for rough cactus coral.

7.2.19.4.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section consists of abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the rough cactus coral.

Rough cactus coral is usually uncommon or rare according to published and unpublished records, indicating that it constitutes < 0.1 percent species contribution (percent of all colonies counted) and occurs at densities < 0.8 colonies per 10 m^2 in Florida and at 0.8 colonies per 100 m transect in Puerto Rico sites sampled by the Atlantic and Gulf Rapid Reef Assessment (Brainard et al. 2011b; Veron 2002; Wagner et al. 2010). Recent monitoring data (e.g., since 2000) from Florida (National Park Service permanent monitoring stations), La Parguera Puerto Rico, and St. Croix (U.S. Virgin Islands/NOAA Center for Coastal Monitoring and Assessment randomized monitoring stations) show *Mycetophyllia ferox* cover to be consistently low with occasional observations of cover by this species of up to two percent and no apparent temporal trend (Brainard et al. 2011b).

Rough cactus coral may have been more abundant in the upper Florida Keys in the early mid-1970s (the methods are not well described for that study) than current observations based on data from Dustan (1977). Long-term Coral Reef Ecological Monitoring Program data from Florida containing species presence/absence information from fixed sites (stations) show a dramatic decline; for 97 stations in the main Florida Keys, occurrence had declined from 20 stations in 1996 to four stations in 2009; in Dry Tortugas occurrence had declined from eight out of twenty-one stations in 2004 to three stations in 2009 (Brainard et al. 2011b).

According to the International Union for Conservation of Nature (IUCN) Species Account and the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (i.e., CITES) species database, rough cactus coral occurs throughout the U.S. waters of the western Atlantic but has not been reported from Flower Garden Banks (Hickerson et al. 2008). The following areas include locations within federally protected waters where rough cactus coral has been observed and recorded (cited in Brainard et al. 2011b): Dry Tortugas National Park; Virgin Island National Park/Monument; Florida Keys National Marine Sanctuary; Navassa Island National Wildlife Refuge; Biscayne National Park; Buck Island Reef National Monument.

On reefs where rough cactus coral is found, it generally occurs at abundances of less than one colony per approximately 10 m squared and percent cover of less than 0.1 (Burman et al. 2012). Based on population estimates, there are at least hundreds of thousands of rough cactus coral colonies present in the Florida Keys and Dry Tortugas combined. Absolute abundance is higher than the estimate from these two locations given the presence of this species in many other locations throughout its range. Low encounter rate and percent cover coupled with the tendency to include *Mycetophyllia* spp. at the genus level make it difficult to discern population trends of rough cactus coral from monitoring data. However, reported losses of rough cactus coral from monitoring stations in the Florida Keys and Dry Tortugas (63-80 percent loss) indicate population decline in these locations. Based on declines in Florida, we conclude rough cactus coral has likely declined throughout its range, and will continue to decline based on increasing threats. As a result, it is presumed that genetic diversity for the species is low.

7.2.19.4.2.1 Status

Rough cactus coral has declined due to disease in at least a portion of its range and has low recruitment, which limits its capacity for recovery from mortality events and exacerbates vulnerability to extinction. Its depth range of 5 to 90 m moderates vulnerability to extinction over the foreseeable future because deeper areas of its range will usually have lower temperatures than surface waters. Acidification is predicted to accelerate most in deeper and cooler waters than those in which the species occurs. Its habitat includes shallow and mesophotic reefs which moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. Rough cactus coral is usually uncommon to rare throughout its range. Its abundance, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time.

Density of rough cactus coral in southeast Florida and the Florida Keys was approximately 0.8 colonies per approximately 10 m^2 between 2005 and 2007. In a survey of 97 stations in the Florida Keys, rough cactus coral declined in occurrence from 20 stations in 1996 to 4 stations in 2009. At 21 stations in the Dry Tortugas, rough cactus coral declined in occurrence from 8 stations in 2004 to 3 stations in 2009 (Brainard et al. 2011a). This appears to indicate that the species was much more abundant in the upper Florida Keys in the 1970s.

In stratified random surveys in the Florida Keys conducted by Miller et al. (2013b), rough cactus coral ranked 39th out of 47 species in 2005, and the least abundant in 2009 and 2012. Extrapolated population estimates were 1.0 ± 0.7 (SE) million in 2005, 9,500 ± 9,500 (SE) colonies in 2009, and 7,000 ± 7,000 (SE) in 2012. These abundance estimates are based on random surveys, and differences between years are more likely a result of sample design rather than population trends. Miller et al. (2013b) also observed that the approximately 4-8 inch (10-20 cm) diameter size class was the most abundant and equaled the combined abundance of the other size classes. The largest size class observed was 12-15 inches (30-40 cm). Average partial mortality per size class ranged from nearly 1-50% and was greatest in the 8-12 inches (20-30 cm) size class (Miller et al. 2013b).

In the Dry Tortugas, Florida, rough cactus coral ranked 35th most abundant out of 43 species in 2006 and 30th out of 40 in 2008. Population estimates were 0.5 ± 0.4 (SE) million in 2006 and 0.5 ± 0.2 million (SE) in 2008. The number of colonies in 2006 was similar between the 0-4 inches (0-10 cm) and 4-8 inches (10-20 cm) size classes, and the largest colonies were in the 8-12 inches (20-30 cm) size class. Greatest partial mortality was around 10%. Two years later, in 2008, the highest proportion of colonies was in the 8-12 inches (20-30 cm) size class, and the largest colonies were in the 16-20 inches (40-50 cm) size class. The greatest partial mortality was about 60% in the 12-16 inches (30-40 cm) size class; however, the number of colonies at that size were few (Miller et al. 2013b).

Benthic cover of rough cactus coral in the Red Hind Marine Conservation District off St. Thomas, which includes mesophotic coral reefs, was 0.003 ± 0.004% in 2007, accounting for 0.02% of coral cover, and ranking second to last out of 21 coral species (Nemeth et al. 2008; Smith et al. 2010). In the U.S. Virgin Islands between 2001 and 2012, rough cactus coral appeared in 12 of 33 survey sites and accounted for 0.01% of the colonized bottom and 0.07% of the coral cover, ranking as the 13th most common coral species (Smith 2013).

7.2.19.4.3 Critical Habitat

No critical habitat has been designated for rough cactus coral.

7.2.19.4.4 Recovery Goals

No final recovery plan currently exists for rough cactus coral, however a recovery outline was developed in 2014 to serve as interim guidance to direct recovery efforts, including recovery planning, until a final recovery plan is developed and approved for the five coral species listed in September 2017. The recovery goals are the same for all five species with short and long-term goals.

7.2.19.5 Lobed Star, Mountainous Star, and Boulder Star Coral

Lobed, mountainous, and boulder star coral (*Orbicella annularis*, *Orbicella faveolata*, and *Orbicella franksi*) occur in the western Atlantic and greater Caribbean as well as the Flower Garden Banks. Lobed and mountainous star coral may be absent from Bermuda (Figure 48).

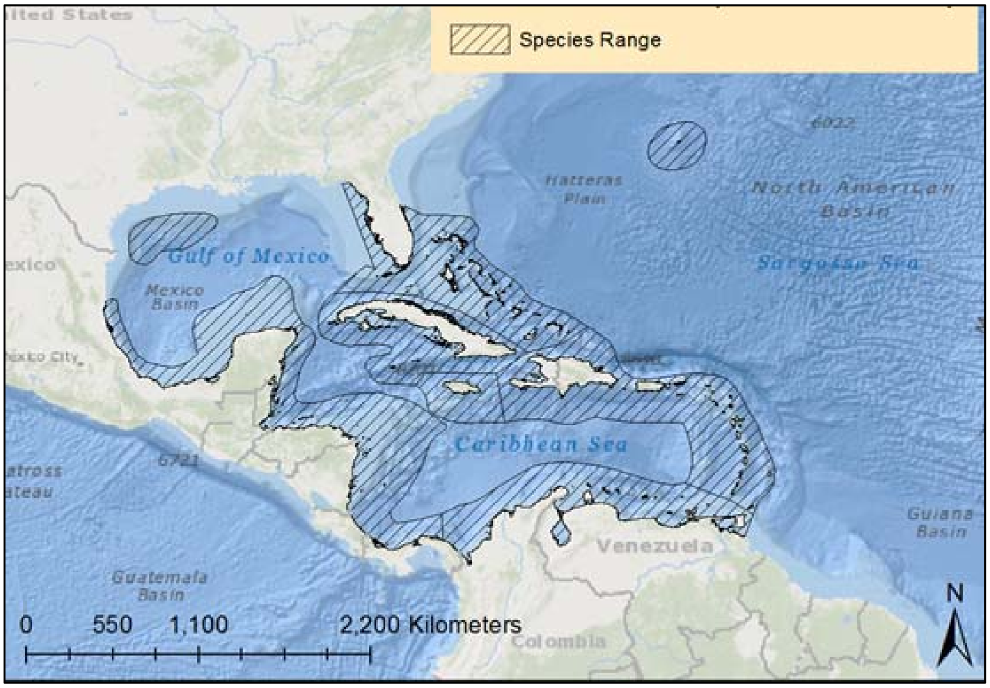


Figure 48. Range map for lobed, mountainous, and boulder star corals.

On September 10, 2014, NMFS listed lobed star, mountainous star, and boulder star coral as threatened (79 FR 53851). Lobed star coral, mountainous star coral, and boulder star coral are the three species in the *Orbicella annularis* star coral complex. These three species were formerly in the genus *Montastraea*; however, recent work has reclassified the three species in the *annularis* complex to the genus *Orbicella* (Budd et al. 2012). The star coral species complex was historically one of the primary reef framework builders throughout the wider Caribbean. The complex was considered a single species – *Montastraea annularis* – with varying growth forms ranging from columns, to massive boulders, to plates. In the early 1990s, Weil and Knowlton (1994) suggested the partitioning of these growth forms into separate species, resurrecting the previously described taxa, *Montastraea* (now *Orbicella*) *faveolata* and *Montastraea* (now *Orbicella*) *franksi.* The three species were differentiated on the basis of morphology, depth range, ecology, and behavior (Weil and Knowton 1994). Subsequent reproductive and genetic studies have supported the partitioning of the *annularis* complex into three species.

Some studies report on the star coral species complex rather than individual species since visual distinction can be difficult where colony morphology cannot be discerned (e.g. small colonies or photographic methods). Information from these studies is reported for the species complex. Where species-specific information is available, it is reported. However, information about

Orbicella annularis published prior to 1994 will be attributed to the species complex since it is dated prior to the split of *Orbicella annularis* into three separate species.

Lobed Star Coral

Lobed star coral colonies grow in columns that exhibit rapid and regular upward growth. In contrast to the other two star coral species, margins on the sides of columns are typically dead. Live colony surfaces usually lack ridges or bumps.

Lobed star coral is reported from most reef environments within the Caribbean (except for Bermuda) in depths of approximately 0.5-20 m. The star coral species complex is a common, often dominant component of Caribbean mesophotic (e.g., > 30 m) reefs, suggesting the potential for deep refuge across a broader depth range, but lobed star coral is generally described with a shallower distribution.

Mountainous Star Coral

Mountainous star coral grows in heads or sheets, the surface of which may be smooth or have keels or bumps. The skeleton is much less dense than in the other 2 star coral species. Colony diameters can reach up to 33 ft (10 m) with heights of 13-16 ft (4-5 m).

Mountainous star coral occurs in the western Atlantic and throughout the Caribbean, including Bahamas, Flower Garden Banks, and the entire Caribbean coastline. There is conflicting information on whether or not it occurs in Bermuda. Mountainous star coral has been reported in most reef habitats and is often the most abundant coral at 33-66 ft (10-20 m) in fore-reef environments. The depth range of mountainous star coral has been reported as approximately 1.5-132 ft (0.5-40 m), though the species complex has been reported to depths of 295 ft (90 m), indicating mountainous star coral's depth distribution is likely deeper than 132 ft (40 m). Star coral species are a common, often dominant component of Caribbean mesophotic reefs (e.g., > 100 ft [30 m]), suggesting the potential for deep refugia for mountainous star coral.

Boulder Star Coral

Boulder star coral is distinguished by large, unevenly arrayed polyps that give the colony its characteristic irregular surface. Colony form is variable, and the skeleton is dense with poorly developed annual bands. Colony diameter can reach up to 5 m with a height of up to 2 m.

Boulder star coral is distributed in the western Atlantic Ocean and throughout the Caribbean Sea including in the Bahamas, Bermuda, and the Flower Garden Banks. Boulder star coral tends to have a deeper distribution than the other 2 species in the *Orbicella* species complex. It occupies most reef environments and has been reported from water depths ranging from approximately 16-165 ft (5-50 m), with the species complex reported to 250 ft (90 m). *Orbicella* species are a common, often dominant, component of Caribbean mesophotic reefs (e.g., >100 ft [30 m]), suggesting the potential for deep refugia for boulder star coral.

7.2.19.5.1 Life history

The star coral species complex has growth rates ranging from 0.06-1.2 cm per year and averaging approximately one centimeter in linear growth per year. The reported growth rate of lobed star coral is 0.4 to 1.2 cm per year (Cruz-Piñón et al. 2003; Tomascik 1990). They grow slower in deep and murky waters.

All three species of the star coral complex are hermaphroditic broadcast spawners, with spawning concentrated on six to eight nights following the full moon in late August, September, or early October depending on location and timing of the full moon. All three species are largely self-incompatible (Knowlton et al. 1997; Szmant et al. 1997). Further, mountainous star coral is largely reproductively incompatible with boulder star coral and lobed star coral, and it spawns about one to two hours earlier. Fertilization success measured in the field was generally below 15 percent for all three species, as it is closely linked to the number of colonies concurrently spawning. Lobed star coral is reported to have slightly smaller egg size and potentially smaller size/age at first reproduction that the other two species of the *Orbicella* genus. In Puerto Rico, minimum size at reproduction for the star coral species complex was 83 cm^2.

Successful recruitment by the star coral complex species has seemingly always been rare. Only a single recruit of *Orbicella* was observed over 18 years of intensive observation of twelve square meters of reef in Discovery Bay, Jamaica. Many other studies throughout the Caribbean also report negligible to absent recruitment of the species complex.

Lobed Star Coral

In addition to low recruitment rates, lobed star corals have late reproductive maturity. Colonies can grow very large and live for centuries. Large colonies have lower total mortality than small colonies, and partial mortality of large colonies can result in the production of clones. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the lobed star coral species complex in the past (Bruckner 2012). Large colonies in the species complex maintain the population until conditions favorable for recruitment occur; however, poor conditions can influence the frequency of recruitment events. While the life history strategy of the star coral species complex has allowed the taxa to remain abundant, the buffering capacity of this life history strategy has likely been reduced by recent population declines and partial mortality, particularly in large colonies.

Mountainous Star Coral

Life history characteristics of mountainous star coral is considered intermediate between lobed star coral and boulder star coral especially regarding growth rates, tissue regeneration, and egg size. Spatial distribution may affect fecundity on the reef, with deeper colonies of mountainous star coral being less fecund due to greater polyp spacing. Reported growth rates of mountainous star coral range between 0.12 and 0.64 inches (0.3 and 1.6 cm) per year (Cruz-Piñón et al. 2003; Tomascik 1990; Villinski 2003; Waddell 2005). Graham and van Woesik (2013) report that 44% of small colonies of mountainous star coral in Puerto Morelos, Mexico that resulted from partial colony mortality produced eggs at sizes smaller than those typically characterized as being mature. The number of eggs produced per unit area of smaller fragments was significantly less than in larger size classes. Szmant and Miller (2005) reported low post-settlement survivorship for mountainous star coral transplanted to the field with only 3-15 percent remaining alive after

30 days. Post-settlement survivorship was much lower than the 29 percent observed for elkhorn coral after 7 months (Szmant and Miller 2005).

Mountainous star coral has slow growth rates, late reproductive maturity, and low recruitment rates. Colonies can grow very large and live for centuries. Large colonies have lower total mortality than small colonies, and partial mortality of large colonies can result in the production of clones. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the star coral species complex in the past (Bruckner 2012). Large colonies in the species complex maintain the population until conditions favorable for recruitment occur; however, poor conditions can influence the frequency of recruitment events. While the life history strategy of the star coral species complex has allowed the taxa to remain abundant, we conclude that the buffering capacity of this life history strategy has been reduced by recent population declines and partial mortality, particularly in large colonies.

Boulder Star Coral

Of 351 boulder star coral colonies observed to spawn at a site off Bocas del Toro, Panama, 324 were unique genotypes. Over 90 percent of boulder star coral colonies on this reef were the product of sexual reproduction, and 19 genetic individuals had asexually propagated colonies made up of 2 to 4 spatially adjacent clones of each. Individuals within a genotype spawned more synchronously than individuals of different genotypes. Additionally, within 16 ft (5 m), colonies nearby spawned more synchronously than farther spaced colonies, regardless of genotype. At distances greater than 16 ft (5 m), spawning was random between colonies (Levitan et al. 2011).

In addition to low recruitment rates, lobed star corals have late reproductive maturity. Colonies can grow very large and live for centuries. Large colonies have lower total mortality than small colonies, and partial mortality of large colonies can result in the production of clones. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the lobed star coral species complex in the past (Bruckner 2012). Large colonies in the species complex maintain the population until conditions favorable for recruitment occur; however, poor conditions can influence the frequency of recruitment events. While the life history strategy of the star coral species complex has allowed the taxa to remain abundant, the buffering capacity of this life history strategy has likely been reduced by recent population declines and partial mortality, particularly in large colonies.

7.2.19.5.2 Population Dynamics

Lobed Star Coral

Information on lobed star coral status and populations dynamics is infrequently documented throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations were data exist.

Lobed star coral has been described as common overall. Demographic data collected in Puerto Rico over 9 years before and after the 2005 bleaching event showed that population growth rates were stable in the pre-bleaching period (2001–2005) but declined one year after the bleaching event. Population growth rates declined even further 2 years after the bleaching event, but they returned and then stabilized at the lower rate the following year.

In the Florida Keys, abundance of lobed star coral ranked 30 out of 47 coral species in 2005, 13 out of 43 inches 2009, and 12 out of 40 inches 2012. Extrapolated population estimates from stratified random samples were 5.6 million ± 2.7 million (SE) in 2005, 11.5 million ± 4.5 million (SE) in 2009, and 24.3 million ± 12.4 million (SE) in 2012. Size class distribution was somewhat variable between survey years, with a larger proportion of colonies in the smaller size classes in 2005 compared to 2009 and 2012 and a greater proportion of colonies in the greater than 36 inches (90 cm) size class in 2012 compared to 2005 and 2009. Partial colony mortality was lowest at less than 4 inches (10 cm; as low as approximately 5 percent) and up to approximately 70 percent in the larger size classes. In the Dry Tortugas, Florida, abundance of lobed star coral ranked 41 out of 43 in 2006 and 31 out of 40 in 2008. The extrapolated population estimate was 0.5 million ± 0.3 million (SE) colonies in 2008. Differences in population estimates between years may be attributed to sampling effort rather than population trends (Miller et al. 2013b).

Colony density varies by habitat and location, and ranges from less than 0.1 to greater than one colony per approximately 10 m^2. In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of lobed star coral ranged between 0.09 and 0.84 colonies per approximately 10 m^2 and was highest on mid-channel reefs followed by inshore reefs, offshore patch reefs, and fore-reefs (Burman et al. 2012). Along the east coast of Florida, density was highest in areas south of Miami (0.34 colonies per approximately 10 m^2) compared to Palm Beach and Broward Counties (0.04 colonies per ~10 m^2; Burman et al. 2012). In surveys between 2005 and 2007 along the Florida reef tract from Martin County to the lower Florida Keys, density of lobed star coral was approximately 1.3 colonies per approximately 10 m^2 (Wagner et al. 2010). Off southwest Cuba on remote reefs, lobed star coral density was 0.31 ± 0.46 (SD) per approximately 30 ft (10 m) transect on 38 reef-crest sites and 1.58 ± 1.29 colonies per approximately 30 ft (10 m) transect on 30 reef-front sites. Colonies with partial mortality were far more frequent than those with no partial mortality which only occurred in the size class less than 40 inches (100 cm) (Alcolado et al. 2010a).

Population trends are available from a number of studies. In a study of sites inside and outside a marine protected area in Belize, lobed star coral cover declined significantly over a 10-year period (1998/99 to 2008/09) (Huntington et al. 2011). In a study of 10 sites inside and outside of a marine reserve in the Exuma Cays, Bahamas, cover of lobed star coral increased between 2004 and 2007 inside the protected area and decreased outside the protected area (Mumby and Harborne 2010). Between 1996 and 2006, lobed star coral declined in cover by 37 percent in permanent monitoring stations in the Florida Keys (Waddell and Clarke 2008a). Cover of lobed star coral declined 71 percent in permanent monitoring stations between 1996 and 1998 on a reef in the upper Florida Keys (Porter et al. 2001).

Mountainous Star Coral

Information on mountainous star coral status and populations dynamics is infrequently documented throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations were data exist.

Information regarding population structure is limited. Observations of mountainous star coral from 182 sample sites in the upper and lower Florida Keys and Mexico showed 3 well-defined populations based on 5 genetic markers, but the populations were not stratified by geography, indicating they were shared among the 3 regions (Baums et al. 2010). Of 10 mountainous star coral colonies observed to spawn at a site off Bocas del Toro, Panama, there were only 3 genotypes (Levitan et al. 2011) potentially indicating 30 percent clonality.

Extrapolated population estimates from stratified random samples in the Florida Keys were 39.7 ± 8 million (SE) colonies in 2005, 21.9 ± 7 million (SE) colonies in 2009, and 47.3 ± 14.5 million (SE) colonies in 2012. The greatest proportion of colonies tended to fall in the 4-8 inches (10-20 cm) and 8-12 inches (20-30 cm) size classes in all survey years, but there was a fairly large proportion of colonies in the greater than 36-inch (90 cm) size class. Partial mortality of the colonies was between 10% and 60% of the surface across all size classes. In the Dry Tortugas, Florida, mountainous star coral ranked seventh most abundant out of 43 coral species in 2006 and fifth most abundant out of 40 in 2008. Extrapolated population estimates were 36.1 ± 4.8 million (SE) colonies in 2006 and 30 ± 3.3 million (SE) colonies in 2008. The size classes with the largest proportion of colonies were 4-8 inches (10-20 cm) and 8-12 inches (20-30 cm), but there was a fairly large proportion of colonies in the greater-than-36-inch (90 cm) size class. Partial mortality of the colonies ranged between approximately 2 percent and 50 percent. Because these population abundance estimates are based on random surveys, differences between years may be attributed to sampling effort rather than population trends (Miller et al. 2013b).

In a survey of 31 sites in Dominica between 1999 and 2002, mountainous star coral was present at 80 percent of the sites at 1-10% cover (Steiner 2003a). In a 1995 survey of 16 reefs in the Florida Keys, mountainous star coral ranked as the coral species with the second highest percent cover (Murdoch and Aronson 1999). On 84 patch reefs (10 ft [3 m] to 16.5 ft [5 m] depth) spanning 149 miles (240 km) in the Florida Keys, mountainous star coral was the third most abundant coral species comprising 7 percent of the 17,568 colonies encountered. It was present at 95 percent of surveyed reefs between 2001 and 2003 (Lirman and Fong 2007). In surveys of 280 sites in the upper Florida Keys in 2011, mountainous star coral was present at 87 percent of sites visited (Miller et al. 2011b). In 2003 on the East Flower Garden Bank, mountainous star coral comprised 10 percent of the 76.5 percent coral cover on reefs 105-132 ft (32-40 m), and partial mortality due to bleaching, disease, and predation were rare at monitoring stations (Precht et al. 2005).

Colony density ranges from approximately 0.1-1.8 colonies per 10 m^2 and varies by habitat and location. In surveys along the Florida reef tract from Martin County to the lower Florida Keys, density of mountainous star coral was approximately 1.6 colonies per 10 m squared (Wagner et al. 2010). On remote reefs off southwest Cuba, density of mountainous star coral was 0.12 ± 0.20 (SE) colonies per 33 ft (10 m) transect on 38 reef-crest sites and 1.26 ± 1.06 (SE) colonies per 33 ft (10 m) transect on 30 reef-front sites (Alcolado et al. 2010a). In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of mountainous star coral ranged between 0.17 and 1.75 colonies per 108 ft^2 and was highest on mid-channel reefs followed by offshore patch reefs and fore-reefs (Burman et al. 2012). Along the east coast of Florida, density was highest in areas south of Miami at 0.94 colonies per 10 m^2 compared to 0.11 colonies per 10 m^2 in Palm Beach and Broward Counties (Burman et al. 2012).

Boulder Star Coral

Boulder star coral is reported as common. In a 1995 survey of 16 reefs in the Florida Keys, boulder star coral had the highest percent cover of all species (Murdoch and Aronson 1999). In surveys throughout the Florida Keys, boulder star coral in 2005 ranked as the 26th most abundant out of 47 coral species, 32nd out of 43 in 2009, and 33rd out of 40 in 2012. Extrapolated population estimates from stratified random surveys were 8.0 ± 3.5 million (SE) colonies in 2005, 0.3 ± 0.2 million (SE) colonies in 2009, and 0.4 ± 0.4 million (SE) colonies in 2012. The authors note that differences in extrapolated abundance between years were more likely a function of sampling design rather than an indication of population trends. In 2005, the greatest proportions of colonies were in the smaller size classes of approximately 10-20 cm and approximately 20-30 cm. Partial colony mortality ranged from zero percent to approximately 73 percent and was generally higher in larger colonies (Miller et al. 2013b).

In the Dry Tortugas, Florida, boulder star coral ranked fourth highest in abundance out of 43 coral species in 2006 and 8th out of 40 in 2008. Extrapolated population estimates were 79 ± 19 million (SE) colonies in 2006 and 18.2 ± 4.1 million (SE) colonies in 2008. Miller et al. (2013b) notes the difference in estimates between years was more likely a function of sampling design rather than population decline. In the first year of the study (2006), the greatest proportion of colonies were in the size class approximately 20-30 cm with twice as many colonies as the next most numerous size class and a fair number of colonies in the largest size class of greater than 90 cm. Partial colony mortality ranged from approximately 10-55 percent. Two years later (2008), no size class was found to dominate, and proportion of colonies in the medium-to-large size classes (approximately 60-90 cm) appeared to be less than in 2006. The number of colonies in the largest size class of greater than 90 cm remained consistent. Partial colony mortality ranged from approximately 15-75 percent (Miller et al. 2013b).

Abundance in Curaçao and Puerto Rico appears to be stable over an eight to ten year period. In Curaçao, abundance was stable between 1997 and 2005, with partial mortality similar or less in 2005 compared to 1998 (Bruckner and Bruckner 2006). Abundance was also stable between 1998-2008 at nine sites off Mona and Desecheo Islands, Puerto Rico. In 1998, four percent of all corals at six sites surveyed off Mona Island were boulder star coral colonies and approximately five percent in 2008; at Desecheo Island, about two percent of all coral colonies were boulder star coral in both 2000 and 2008 (Bruckner and Hill 2009).

Based on population estimates, there are at least tens of millions of colonies present in both the Dry Tortugas and U.S. Virgin Islands. Absolute abundance is higher than the estimate from these two locations given the presence of this species in many other locations throughout its range. The frequency and extent of partial mortality, especially in larger colonies of boulder star coral, appear to be high in some locations such as Florida and Cuba, though other locations like the Flower Garden Banks appear to have lower amounts of partial mortality. A decrease in boulder star coral percent cover by 38 percent and a shift to smaller colony size across five countries suggest that population decline has occurred in some areas; colony abundance appears to be stable in other areas. We anticipate that while population decline has occurred, boulder star coral is still common with the number of colonies at least in the tens of millions. Additionally, we conclude that the buffering capacity of boulder star coral's life history strategy that has allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies. We also anticipate that the population abundance is likely to decrease in the future with increasing threats.

The star coral species complex has growth rates ranging from 0.06-1.2 cm per year and averaging approximately one-centimeter linear growth per year. Boulder star coral is reported to be the slowest of the three species in the complex (Brainard et al. 2011b). They grow slower in deep or murky waters.

Of 351 boulder star coral colonies observed to spawn at a site off Bocas del Toro, Panama, 324 were unique genotypes. Over 90 percent of boulder star coral colonies on this reef were the product of sexual reproduction, and 19 genetic individuals had asexually propagated colonies made up of two to four spatially adjacent clones of each. Individuals within a genotype spawned more synchronously than individuals of different genotypes. Additionally, within five meters, colonies nearby spawned more synchronously than farther spaced colonies, regardless of genotype. At distances greater than five meters, spawning was random between colonies (Levitan et al. 2011).

7.2.19.5.3 Status

Lobed star coral

Lobed star coral was historically considered to be one of the most abundant species in the Caribbean (Weil and Knowton 1994). Percent cover has declined to between 37 percent and 90 percent over the past several decades at reefs at Jamaica, Belize, Florida Keys, The Bahamas, Bonaire, Cayman Islands, Curaçao, Puerto Rico, U.S. Virgin Islands, and St. Kitts and Nevis. Based on population estimates, there are at least tens of millions of lobed star coral colonies present in the Florida Keys and Dry Tortugas combined. Absolute abundance is higher than the estimate from these two locations given the presence of this species in many other locations throughout its range. Lobed star coral remains common in occurrence. Abundance has decreased in some areas to between 19 and 57 percent, and shifts to smaller size classes have occurred in locations such as Jamaica, Colombia, The Bahamas, Bonaire, Cayman Islands, Puerto Rico, U.S. Virgin Islands, and St. Kitts and Nevis. At some reefs, a large proportion of the population is comprised of non-fertile or less-reproductive size classes. Several population projections indicate population decline in the future is likely at specific sites, and local extirpation is possible within 25-50 years at conditions of high mortality, low recruitment, and slow growth rates. We conclude that while substantial population decline has occurred in lobed star coral, it is still common throughout the Caribbean and remains one of the dominant species numbering at least in the tens of millions of colonies. We conclude that the buffering capacity of lobed star coral's life history strategy that has allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies. We also conclude that the population abundance is likely to decrease in the future with increasing threats.

Population trends are available from a number of studies. In a study of sites inside and outside a marine protected area in Belize, lobed star coral cover declined significantly over a ten year period (1998/99 to 2008/09) (Huntington et al. 2011). In a study of ten sites inside and outside of a marine reserve in the Exuma Cays, Bahamas, cover of lobed star coral increased between 2004 and 2007 inside the protected area and decreased outside the protected area (Mumby and Harborne 2010).

Asexual fission and partial mortality can lead to multiple clones of the same colony. The percentage of unique individuals is variable by location and is reported to range between 18 percent and 86 percent (thus, 14-82 percent are clones). Colonies in areas with higher disturbance from hurricanes tend to have more clonality. Genetic data indicate that there is some population structure in the eastern, central, and western Caribbean with population connectivity within but not across areas. Although lobed star coral is still abundant, it may exhibit high clonality in some locations, meaning that there may be low genetic diversity.

Lobed star coral has undergone major declines mostly due to warming-induced bleaching and disease. Several population projections indicate population decline in the future is likely at specific sites and that local extirpation is possible within 25-50 years at conditions of high mortality, low recruitment, and slow growth rates. There is evidence of synergistic effects of threats for this species including disease outbreaks following bleaching events and increased disease severity with nutrient enrichment. Lobed star coral is highly susceptible to a number of threats, and cumulative effects of multiple threats have likely contributed to its decline and exacerbate vulnerability to extinction. Despite high declines, the species is still common and remains one of the most abundant species on Caribbean reefs. Its life history characteristics of large colony size and long life span have enabled it to remain relatively persistent despite slow growth and low recruitment rates, thus moderating vulnerability to extinction. However, the buffering capacity of these life history characteristics is expected to decrease as colonies shift to smaller size classes, as has been observed in locations in the species' range. Its absolute population abundance has been estimated as at least tens of millions of colonies in the Florida Keys and Dry Tortugas combined and is higher than the estimate from these two locations due to the occurrence of the species in many other areas throughout its range. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because lobed star coral is limited to an area with high localized human impacts and predicted increasing threats. Star coral occurs in most reef habitats 0.5-20 m in depth which moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience high temperature variation and ocean chemistry at any given point in time. Its abundance and life history characteristics, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. We also anticipate that the population abundance is likely to decrease in the future with increasing threats.

In the Florida Keys, abundance of lobed star coral ranked 30 out of 47 coral species in 2005, 13 out of 43 in 2009, and 12 out of 40 in 2012. Extrapolated population estimates from stratified random samples were 5.6 million ± 2.7 million (SE) in 2005, 11.5 million ± 4.5 million (SE) in 2009, and 24.3 million ± 12.4 million (SE) in 2012. Size class distribution was somewhat variable between survey years, with a larger proportion of colonies in the smaller size classes in 2005 compared to 2009 and 2012 and a greater proportion of colonies in the greater than 90 cm size class in 2012 compared to 2005 and 2009. Partial colony mortality was lowest at less than ten centimeters (as low as approximately five percent) and up to approximately 70 percent in the larger size classes. Between 1996 and 2006, lobed star coral declined in cover by 37 percent in permanent monitoring stations in the Florida Keys (Waddell and Clarke 2008a). Cover of lobed star coral declined 71 percent in permanent monitoring stations between 1996 and 1998 on a reef in the upper Florida Keys (Porter et al. 2001).

In the Dry Tortugas, Florida, abundance of lobed star coral ranked 41 out of 43 in 2006 and 31 out of 40 in 2008. The extrapolated population estimate was 0.5 million ± 0.3 million (SE) colonies in 2008. Differences in population estimates between years may be attributed to sampling effort rather than population trends (Miller et al. 2013b).

Cover of lobed star coral at Yawzi Point, St. John, U.S. Virgin Islands declined from 41 percent in 1988 to approximately 12 percent by 2003 as a rapid decline began with the aftermath of Hurricane Hugo in 1989. The decline began between 1994 and 1999 during a time of 2 hurricanes (1995) and a year of unusually high sea temperature (1998) but percent cover remained statistically unchanged between 1999 and 2003. Colony abundances declined from 47 to 20 colonies per approximately 1 m^2 between 1988 and 2003, due mostly to the death and fission of medium-to-large colonies (≥ 24 square inches [151 cm^2]). Meanwhile, the population size class structure shifted between 1988 and 2003 to a higher proportion of smaller colonies in 2003 (60% less than 7 square inches [50 cm^2] in 1988 versus 70% in 2003) and lower proportion of large colonies (6% greater than 39 square inches [250 cm^2] in 1988 versus 3% in 2003). The changes in population size structure indicated a population decline coincident with the period of apparent stable coral cover. Population modeling forecasted the 1988 size structure would not be reestablished by recruitment and a strong likelihood of extirpation of lobed star coral at this site within 50 years (Edmunds and Elahi 2007).

Star corals are the third most abundant coral by percent cover in permanent monitoring stations in the U.S. Virgin Islands. A decline of 60 percent was observed between 2001 and 2012 primarily due to bleaching in 2005. However, most of the mortality was partial mortality and colony density in monitoring stations did not change (Smith 2013).

Mountainous Star Coral

Population trend data exists for several locations. In a survey of 185 sites in 5 countries (Bahamas, Bonaire, Cayman Islands, Puerto Rico, and St. Kitts and Nevis) between 2010 and 2011, size of mountainous star coral colonies was significantly greater than boulder star coral and lobed star coral. The total mean partial mortality of mountainous star coral at all sites was 38 percent. The total live area occupied by mountainous star coral declined by a mean of 65 percent, and mean colony size declined from 43 ft^2 to 15 ft^2. At the same time, there was a 168 percent increase in small tissue remnants less than 5 ft^2, while the proportion of completely live large colonies decreased. Mountainous star coral colonies in Puerto Rico were much larger and sustained higher levels of mortality compared to the other 4 countries. Colonies in Bonaire were also large, but they experienced much lower levels of mortality. Mortality was attributed primarily to outbreaks of white plague and yellow band disease, which emerged as corals began recovering from mass bleaching events. This was followed by increased predation and removal of live tissue by damselfish to cultivate algal lawns (Bruckner 2012).

Based on population estimates, there are at least tens of millions of colonies present in each of several locations including the Florida Keys, Dry Tortugas, and the U.S. Virgin Islands. Absolute abundance is higher than the estimate from these 3 locations given the presence of this species in many other locations throughout its range. Population decline has occurred over the past few decades with a 65 percent loss in mountainous star coral cover across 5 countries. High partial mortality of colonies has led to smaller colony sizes and a decrease of larger colonies in some locations such as The Bahamas, Bonaire, Puerto Rico, Cayman Islands, and St. Kitts and Nevis. We conclude that mountainous star coral has declined but remains common and likely has at least tens of millions of colonies throughout its range. Additionally, as discussed in the genus section, we conclude that the buffering capacity of mountainous star coral's life history strategy which has allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies. We also conclude that the population abundance is likely to decrease in the future with increasing threats.

At 9 sites off Mona and Desecheo Islands, Puerto Rico, no species extirpations were noted at any site over 10 years of monitoring between 1998 and 2008 (Bruckner and Hill 2009). Both mountainous star coral and lobed star coral sustained large losses during the period. The number of colonies of mountainous star coral decreased by 36 percent and 48 percent at Mona and Desecheo Islands, respectively (Bruckner and Hill 2009). In 1998, 27 percent of all corals at 6 sites surveyed off Mona Island were mountainous star coral colonies, but this statistic decreased to approximately 11 percent in 2008 (Bruckner and Hill 2009). At Desecheo Island, 12 percent of all coral colonies were mountainous star coral in 2000, compared to 7percent in 2008. Losses of mountainous star coral from Mona and Descheo Islands, Puerto Rico include a 36-48 percent reduction in abundance and a decrease of 42-59 percent in its relative abundance (i.e., proportion relative to all coral colonies).

Mountainous star coral is the sixth most abundant species by percent cover in permanent monitoring stations in the U.S. Virgin Islands. The star coral species complex had the highest abundance at these stations and included all colonies where species identification was uncertain. Population estimates in the 19 square miles (49 km^2) of the Red Hind Marine Conservation District are at least 16 million colonies of mountainous star corals (Smith 2013).

Partial colony mortality is lower in some areas such as the Flower Garden Banks as compared to sites such as Mona and Desecheo Islands.

Boulder Star Coral

Information on boulder star coral status and population dynamics is infrequently documented throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations were data exist.

On remote reefs off southwest Cuba, colony density was 0.083 ± 0.17 (SD) per ~100 ft^2 (10 m^2) transect on 38 reef-crest sites and 1.05 ± 1.02 colonies per ~100 ft^2 (10 m^2) transect on 30 reef-front sites (Alcolado et al. 2010a). The number of boulder star coral colonies in Cuba with partial colony mortality were far more frequent than those with no mortality across all size classes, except for 1 (i.e., less than ~20 inches [50 cm]) that had similar frequency of colonies with and without partial mortality (Alcolado et al. 2010a).

Abundance in Curaçao and Puerto Rico appears to be stable over an 8 to 10 year period. In Curaçao, abundance was stable between 1997 and 2005, with partial mortality similar or less in 2005 compared to 1998 (Bruckner and Bruckner 2006). Abundance was also stable between 1998-2008 at 9 sites off Mona and Desecheo Islands, Puerto Rico (Bruckner and Hill 2009).

On the other hand, colony size has decreased over the past several decades. Bruckner conducted a survey of 185 sites (2010 and 2011) in 5 countries (The Bahamas, Bonaire, Cayman Islands, Puerto Rico, and St. Kitts and Nevis) and reported the size of boulder star coral and lobed star coral colonies as significantly smaller than mountainous star coral. The total mean partial mortality of boulder star coral was 25 percent. Overall, the total live area occupied by boulder star coral declined by a mean of 38 percent, and mean colony size declined from 210 square inches to 131 square inches. At the same time, there was a 137 percent increase in small tissue remnants, along with a decline in the proportion of large, completely alive colonies. Mortality was attributed primarily to outbreaks of white plague and yellow band disease, which emerged as corals began recovering from mass bleaching events. This was followed by increased predation and removal of live tissue by damselfish to cultivate algal lawns (Bruckner 2012).

Based on population estimates, there are at least tens of millions of colonies present in both the Dry Tortugas and U.S. Virgin Islands. Absolute abundance is higher than the estimate from these 2 locations given the presence of this species in many other locations throughout its range. The frequency and extent of partial mortality, especially in larger colonies of boulder star coral, appear to be high in some locations such as Florida and Cuba, though other locations like the Flower Garden Banks appear to have lower amounts of partial mortality. A decrease in boulder star coral percent cover by 38 percent and a shift to smaller colony size across 5 countries suggest that population decline has occurred in some areas; colony abundance appears to be stable in other areas. We anticipate that while population decline has occurred, boulder star coral is still common with the number of colonies at least in the tens of millions. Additionally, we conclude that the buffering capacity of boulder star coral's life history strategy that has allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies. We also anticipate that the population abundance is likely to decrease in the future with increasing threats.

Boulder star coral is reported as common. In a 1995 survey of 16 reefs in the Florida Keys, boulder star coral had the highest percent cover of all species (Murdoch and Aronson 1999). In surveys throughout the Florida Keys, boulder star coral in 2005 ranked 26th most abundant out of 47 coral species, 32nd out of 43 in 2009, and 33rd out of 40 in 2012. Extrapolated population estimates from stratified random surveys were 8.0 ± 3.5 million (SE) colonies in 2005, 0.3 ± 0.2 million (SE) colonies in 2009, and 0.4 ± 0.4 million (SE) colonies in 2012. The authors note that differences in extrapolated abundance between years were more likely a function of sampling design rather than an indication of population trends. In 2005, the greatest proportions of colonies were in the smaller size classes of approximately 4-8 inches (10-20 cm) and approximately 8-12 inches (20-30 cm). Partial colony mortality ranged from 0 percent to approximately 73 percent and was generally higher in larger colonies (Miller et al. 2013b).

In the Dry Tortugas, Florida, boulder star coral ranked 4th highest in abundance out of 43 coral species in 2006 and 8th out of 40 in 2008. Extrapolated population estimates were 79 ± 19 million (SE) colonies in 2006 and 18.2 ± 4.1 million (SE) colonies in 2008. The authors note the difference in estimates between years was more likely a function of sampling design rather than population decline. In the first year of the study (2006), the greatest proportion of colonies were in the size class approximately 8-12 inches (20-30 cm) with twice as many colonies as the next most numerous size class and a fair number of colonies in the largest size class of greater than 3 ft (90 cm). Partial colony mortality ranged from approximately 10-55 percent. Two years later (2008), no size class was found to dominate, and proportion of colonies in the medium-to-large size classes (approximately 24-36 inches) appeared to be less than in 2006. The number of colonies in the largest size class of greater than 3 ft (90 cm) remained consistent. Partial colony mortality ranged from approximately 15-75 percent (Miller et al. 2013b).

In 2003, on the east Flower Garden Bank, boulder star coral comprised 46 percent of the 76.5 percent coral cover on reefs approximately 105-131 ft (32-40 m) in depth. Partial coral mortality due to bleaching, disease and predation was rare in survey stations (Precht et al. 2005). In a survey of 31 sites in Dominica between 1999 and 2002, boulder star coral was present in 7 percent of the sites at less than 1 percent cover (Steiner 2003a).

Reported density is variable by location and habitat and is reported to range from 0.02 to 1.05 colonies per approximately (~) 10 m^2. In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of boulder star coral ranged between 0.04 and 0.47 colonies per ~ 10 m^2 and was highest on the offshore patch reef and fore-reef habitats (Burman et al. 2012). In south Florida, density was highest in areas south of Miami at 0.44 colonies per ~ 10 m^2 compared to 0.02 colonies per ~10 m^2 in Palm Beach and Broward

Counties (Burman et al. 2012). Along the Florida reef tract from Martin County to the lower Florida Keys, density of boulder star coral was ~0.9 colonies per ~ 10 m^2 (Wagner et al. 2010).

In 1998, 4 percent of all corals at 6 sites surveyed off Mona Island were boulder star coral colonies and approximately 5 percent in 2008; at Desecheo Island, about 2 percent of all coral colonies were boulder star coral in both 2000 and 2008 (Bruckner and Hill 2009), meaning abundance of this species was stable at these sites.

In the U.S. Virgin Islands, boulder star coral is the second most abundant species by percent cover at permanent monitoring stations. However, because the species complex, which is the most abundant by cover, was included as a category prior to separating the 3 sibling species, it is likely that boulder star coral is the most abundant, when including mesophotic reefs. Population estimates of boulder star coral in the approximately 19 square mile area of the Red Hind Marine Conservation District are at least 34 million colonies (Smith 2013).

8 ENVIRONMENTAL BASELINE

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 C.F.R. §402.02).

8.1 Global Climate Change

Global annually averaged surface air temperature has increased by about 1.8 degrees Fahrenheit (1.0 degrees Celsius) over the last 115 years (1901 to 2016) (Wuebbles et al. 2017). These global trends are expected to continue over climate timescales. The magnitude of climate change beyond the next few decades will depend primarily on the amount of greenhouse gases (especially carbon dioxide) emitted globally. Without major reductions in emissions, the increase in annual average global temperature relative to preindustrial times could reach nine degrees Fahrenheit (5 degrees Celsius) or more by the end of this century (Wuebbles et al. 2017). With significant reductions in emissions, the increase in annual average global temperature could be limited to 3.6 degrees Fahrenheit (2 degrees Celsius) or less (Wuebbles et al. 2017). The global atmospheric carbon dioxide concentration has now passed 400 parts per million, a level that last occurred about three million years ago, when both global average temperature and sea level were significantly higher than today. There is broad consensus that the further and the faster the Earth system is pushed towards warming, the greater the risk of unanticipated changes and impacts, some of which are potentially large and irreversible (Wuebbles et al. 2017).

Changes in surface, atmospheric, and oceanic temperatures and other climatic changes have resulted in melting glaciers, diminishing snow cover, shrinking sea ice, rising sea levels, ocean acidification, and increasing atmospheric water vapor. Global average sea level has risen by about seven to eight inches since 1900, with almost half (about three inches) of that rise occurring since 1993. Human-caused climate change has made a substantial contribution to this rise since 1900, contributing to a rate of rise that is greater than during any preceding century in at least 2,800 years (Wuebbles et al. 2017). Global sea level rise has already affected the United States. The incidence of daily tidal flooding is accelerating in more than 25 Atlantic and Gulf Coast cities. Global average sea levels are expected to continue to rise by at least several inches in the next 15 years and by one to four feet by 2100. Sea level rise will be higher than the global average on the East and Gulf Coasts of the United States (Wuebbles et al. 2017).

Climate change has been linked to changing ocean currents as well. Rising carbon dioxide levels have been identified as a reason for a poleward shift in the Eastern Australian Current, shifting warm waters into the Tasman Sea and altering biotic features of the area (Poloczanska et al. 2009). Similarly, the Kuroshio Current in the western North Pacific (an important foraging area for juvenile sea turtles) has shifted southward as a result of altered long-term wind patterns over the Pacific Ocean (Poloczanska et al. 2009).

Changes in air and sea surface temperatures can affect marine ecosystems in several ways. Direct effects, decreases in sea ice and changes in ocean acidity, precipitation patterns, and sea level. Indirect effects of climate change include altered reproductive seasons/locations, shifts in migration patterns, reduced distribution and abundance of prey, and changes in the abundance of competitors and/or predators. Variations in sea surface temperature can affect an ecological community's composition and structure, alter migration and breeding patterns of fauna and flora and change the frequency and intensity of extreme weather events. For species that undergo long migrations, individual movements are usually associated with prey availability or habitat suitability. If either is disrupted, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009). Over the long term, increases in sea surface temperature can also reduce the amount of nutrients supplied to surface waters from the deep sea leading to declines in fish populations (EPA 2010), and, therefore, declines in those species whose diets are dominated by fish. Acevedo-Whitehouse and Duffus (2009) proposed that the rapidity of environmental changes, such as those resulting from global warming, can harm immunocompetence and reproductive parameters in wildlife to the detriment of population viability and persistence.

Climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the community structure and function of marine, coastal, and terrestrial ecosystems in the near future (IPCC 2014; McCarty 2001). Climate change will likely have its most pronounced effects on vulnerable species whose populations are already in tenuous positions (Williams et al. 2008b). As such, we expect the risk of extinction to listed species to rise with the degree of climate shift associated with global warming. Increasing atmospheric temperatures have already contributed to documented changes in the quality of freshwater, coastal, and marine ecosystems and to the decline of endangered and threatened species populations (Karl 2009; Mantua et al. 1997).

Climate-related shifts in marine mammal range and distribution have been observed in some populations (Silber et al. 2017). Marine mammal species often exhibit strong dependence on or fidelity to particular habitat types, oceanographic features, and migration routes. Specialized diets, restricted ranges, or reliance on specific substrates or sites (e.g., for pupping) make many marine mammal populations particularly vulnerable to climate change (Silber et al. 2017). Marine mammals with restricted distributions linked to water temperature may be particularly exposed to range restriction (Issac 2009; Learmonth et al. 2006). MacLeod (2009) estimated that, based upon expected shifts in water temperature, 88 percent of cetaceans would be affected by climate change, 47 percent would be negatively affected, and 21 percent would be put at risk of extinction. Of greatest concern are cetaceans with ranges limited to non-tropical waters and preferences for shelf habitats (Macleod 2009).

Shifting ranges of important prey item for marine mammals have been observed across all ocean regions (Poloczanska et al. 2016). Climate change can influence marine mammal reproductive success and fitness by altering prey availability. For example, reduced prey availability resulting from increased sea surface temperatures has been suggested to explain lower rates of conception in female sperm whales (Whitehead 1997). Breeding in many marine mammal species may be timed to coincide with maximum abundance of suitable prey, either for the lactating mother or the calf at weaning, so that any changes in the environmental conditions which determine prey abundance may cause a mismatch in synchrony between predator and prey, either in time or location (Learmonth et al. 2006). Migratory species that travel long distances between feeding and breeding areas may be particularly vulnerable to mismatching.

The distribution, abundance and migration of baleen whales reflects the distribution, abundance and movements of dense prey patches (e.g., copepods, euphausiids or krill, amphipods, shrimp), which have in turn been linked to oceanographic features affected by climate change (Learmonth et al. 2006). Changes in plankton distribution, abundance and composition are closely related to ocean climate, including temperature. For example, Edwards et al. (2007) found a 70 percent decrease in one zooplankton species in the North Sea and an overall reduction in plankton biomass as warm-water species invade formerly cold-water areas. Variations in the recruitment of krill and the reproductive success of krill predators correlate to variations in sea-surface temperatures and the extent of sea-ice coverage during winter months. Curran et al. (2003) analyzed ice-core samples from 1841-1995 and concluded Antarctic sea ice cover had declined by about 20 percent since the 1950s. Atkinson et al. (2004) linked sea ice loss to severe decreases in krill populations over the past several decades in some areas of the Antarctic. Blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Clapham et al. 1999; Payne et al. 1986; Payne et al. 1990).

Sea turtles occupy a wide range of terrestrial and marine habitats, and many aspects of their life history have been demonstrated to be closely tied to climatic variables such as ambient temperature and storminess (Hawkes et al. 2009). Sea turtles have temperature-dependent sex determination, and many populations produce highly female-biased offspring sex ratios, a skew likely to increase further with global warming (Newson et al. 2009; Patrício et al. 2017). Genetic analyses and behavioral data suggest that populations with temperature-dependent sex determination may be unable to evolve rapidly enough to counteract the negative fitness consequences of rapid global temperature change (Hays 2008 as cited in Newson et al. 2009). Altered sex ratios have been observed in sea turtle populations worldwide (Fuentes et al. 2009a;

Mazaris et al. 2008; Reina et al. 2008; Robinson et al. 2008). This does not yet appear to have affected population viabilities through reduced reproductive success, although average nesting and emergence dates have changed over the past several decades by days to weeks in some locations (Poloczanska et al. 2009). Hayes et al. (2010) suggests that because of the increased frequency of male loggerhead breeding (based on visits to breeding sites) versus female breeding, the ability of males to breed with many females and the ability of females to store sperm and fertilize many clutches, skewed sex ratios due to climate change could be compensated for in some turtle populations and population effects may be ameliorated. However, such a fundamental shift in population demographics may cause a fundamental instability in the viability of some populations. In addition to altering sex ratios, increased temperatures in sea turtle nests can result in reduced incubation times (producing smaller hatchling), reduced clutch size, and reduced nesting success due to exceeded thermal tolerances (Azanza-Ricardo et al. 2017; Fuentes et al. 2010; Fuentes et al. 2011; Fuentes et al. 2009b).

Other climatic aspects, such as extreme weather events, precipitation, ocean acidification and sea level rise also have potential to affect marine turtle populations. Changes in global climatic patterns will likely have profound effects on the coastlines of every continent, thus directly impacting sea turtle nesting habitat (Wilkinson and Souter 2008). In some areas, increases in sea level alone may be sufficient to inundate turtle nests and reduce hatching success by creating hypoxic conditions within inundated eggs (Caut et al. 2009; Pike et al. 2015). Flatter beaches, preferred by smaller sea turtle species, would likely be inundated sooner than would steeper beaches preferred by larger species (Hawkes et al. 2014). Relatively small increases in sea level can result in the loss of a large proportion of nesting beaches in some locations. For example, a study in the northwestern Hawaiian Islands predicted that up to 40 percent of green turtle nesting beaches could be flooded with 0.9 m of sea level rise (Baker et al. 2006). The loss of nesting beaches would have catastrophic effects on sea turtle populations globally if they are unable to colonize new beaches that form, or if the newly formed beaches do not provide the habitat attributes (sand depth, temperature regimes, refuge) necessary for egg survival.

Changing patterns of coastal erosion and sand accretion, combined with an anticipated increase in the number and severity of extreme weather events, may further exacerbate the effects of sea level rise on turtle nesting beaches (Wilkinson and Souter 2008). Climate change is expected to affect the intensity of hurricanes through increasing sea surface temperatures, a key factor that influences hurricane formation and behavior (EPA 2010). The intensity of tropical storms in the Atlantic Ocean, Caribbean, and Gulf of Mexico has risen noticeably over the past 20 years and six of the 10 most active hurricane seasons have occurred since the mid-1990s (EPA 2010). Extreme weather events may directly harm sea turtles, causing “mass” strandings and mortality (Poloczanska et al. 2009). Studies examining the spatio-temporal coincidence of marine turtle nesting with hurricanes, cyclones and storms suggest that cyclical loss of nesting beaches, decreased hatching success and hatchling emergence success could occur with greater frequency in the future due to global climate change (Hawkes et al. 2009). Pike et al. (2006) concluded that warming sea surface temperatures may lead to potential fitness consequences in sea turtles resulting from altered seasonality and duration of nesting. Sea turtles may expand their range as temperature-dependent distribution limits change (McMahon and Hays 2006). Warming ocean temperatures may extend poleward the habitat which sea turtles can utilize (Poloczanska et al. 2009).

Global climate change may affect the ESA-listed fish species and DPSs considered in this opinion. Thermal changes of just a few degrees Celsius can substantially alter fish protein metabolism (McCarthy and Houlihan 1997), response to aquatic contaminants (Reid 1997), reproductive performance (Van Der Kraak and Pankhurst 1997), smolt development (McCormick et al. 1997), species distribution limits (McCarthy and Houlihan 1997), and community structure of fish populations (Schindler 2001). Apart from direct changes to anadromous fish survival, increased water temperatures may alter habitat (e.g., Crozier et al. 2014; Mantua et al. 2010).

Shortnose and Atlantic sturgeon are tolerant to water temperatures up to approximately 28° C; these temperatures are experienced naturally in some areas of rivers during the summer months. If temperature rises beyond thermal limits for extended periods, habitat could be lost; this could be the case if southern habitats warm, resulting in range loss (Lassalle et al. 2010). As water temperatures increase, juvenile sturgeon may experience elevated mortality due to lack of cooler water refuges. The Atlantic salmon Gulf of Maine DPS may be particularly vulnerable to elevated water temperature regimes since Maine is near the southern extent species' range in North America (Fay et al. 2006b). Rising temperatures could also exacerbate existing water quality problems associated with dissolved oxygen and temperature.

Salinity plays an important role in the movement and distribution of some nearshore and estuarine fish species (Simpfendorfer et al. 2011). Rising sea levels associated with climate change will likely shift the salt wedge upstream in affected rivers. Given the importance of salinity, changes in freshwater flow regimes into estuaries as a result of climate change will affect fish populations by potentially changing their distributions. Anadromous fish species (e.g., sturgeon and salmon) spawn in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. If the salt wedge moves further upstream, sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the salt wedge would be limited. Simpfendorfer et al. (2011) found that juvenile smalltooth sawfish moved farther inland into estuary reaches within their preferred salinity range. Sea level rise will also likely impact important sawfish mangrove habitats as sediment surface elevations for mangroves will not keep pace with conservative projected rates sea level rise (Gilman et al. 2008).

Changes in precipitation patterns are anticipated as a result of global climate change. The increased rainfall predicted in some areas may increase runoff and scour spawning areas, and flooding events could cause temporary water quality issues. In some areas, longer and more frequent droughts are predicted, in combination with increased water withdrawal for human use, may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, anadromous fish may become susceptible to strandings or habitat restrictions. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology, causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season, which might affect prey availability in rearing habitat. Overall, it is likely that global climate change would increase pressures on the survival and recovery of ESA-listed sturgeon and salmon populations considered in this opinion.

In the NMFS' final rule to list 20 coral species as threatened (79 FR 53851), ocean warming and acidification, associated with climate change, were identified as two of the most important threats to the current or expected future extinction risk of reef building corals. Reef building organisms are predicted to decrease the rate at which they deposit $CaCO_3$ in response to increased ocean acidity and warmer water temperatures (Raymundo et al. 2008). Further, the most severe coral bleaching events observed to date have typically been accompanied by ocean warming events such as the El Niño-Southern Oscillation (Glynn 2001). Bleaching episodes result in substantial loss of coral cover, and result in the loss of important habitat for associated reef fishes and other biota. Corals can typically withstand mild to moderate bleaching, but severe or prolonged bleaching events can lead to coral colony death (79 FR 53851). While the susceptibility to ocean warming and acidification associated with climate change is expected to vary by species and specific coral colony (based on latitude, depth, bathymetry, etc.) (79 FR 53851), climate change is expected to have major impacts on the coral species considered in this opinion.

8.2 Oceanic Temperature Regimes

Oceanographic conditions in the North Atlantic Ocean can be altered due to periodic shifts in atmospheric patterns caused by the North Atlantic oscillation which affects sea surface temperatures, wind conditions, and ocean circulation (Stenseth et al. 2002). The North Atlantic oscillation is an alteration in the intensity of the atmospheric pressure difference between the semi-permanent high-pressure center over the Azores Islands and the sub-polar low-pressure center over Iceland (Stenseth et al. 2002). Sea-level atmospheric pressure in the two regions tends to vary in a "see-saw" pattern – when the pressure increases in Iceland it decreases in the Azores and vice-versa (i.e., the two systems tend to intensity or weaken in synchrony). The North Atlantic oscillation is the dominant mode of decadal-scale variability in weather and climate in the North Atlantic Ocean region (Hurrell 1995).

Decade-scale climatic regime shifts, such as the North Atlantic oscillation, can result in changes in habitat conditions and prey distribution for ESA-listed species (Beamish 1993; Benson and Trites 2002; Hare and Mantua 2001; Mantua et al. 1997; Mundy 2005; Mundy and Cooney 2005; Stabeno et al. 2004). Since ocean circulation is wind and density driven, it is not surprising to find that the North Atlantic oscillation appears to have a direct effect on the position and strength of important North Atlantic Ocean currents. Decadal trends in the North Atlantic oscillation affects the position of the Gulf Stream (Taylor et al. 1998) and other circulation patterns in the North Atlantic Ocean that act as migratory pathways for various marine species, especially fish. A strong association has been established between the variability of the North Atlantic oscillation and changes affecting various trophic groups in North Atlantic marine ecosystems on both the eastern and western sides of the basin (Drinkwater et al. 2003; Fromentin and Planque 1996). For example, the temporal and spatial patterns of *Calanus* copepods (zooplankton) were the first to be linked to the phases of the North Atlantic oscillation (Fromentin and Planque 1996; Stenseth et al. 2002). When the North Atlantic oscillation index was positive, the abundance of *Calanus* copepods in the Gulf of Maine increased, with the inverse true in years when the North Atlantic oscillation index was negative (Conversi et al. 2001; Greene et al. 2003b). Such a shift in copepod patterns has a tremendous significance to upper-trophic-level species, including the North Atlantic right whale, which feeds principally on *Calanus finmarchicus*. North Atlantic right whale calving rates are linked to the abundance of *Calanus finmarchicus*; when the abundance is high, the calving rate remains stable but calving rates decline when the abundance of *C. finmarchicus* declined (Greene et al. 2003a). When the North Atlantic oscillation index is low with subsequently warmer water temperatures off Labrador and the Scotian Shelf, recruitment of cod is higher; direct links to the North Atlantic oscillation phase have also been found for recruitment in the North Atlantic of herring, two tuna species, Atlantic salmon, and swordfish (Drinkwater et al. 2003).

8.3 Anthropogenic Sound

The ESA-listed species that occur in the action area are regularly exposed to multiple sources of anthropogenic sounds. Anthropogenic sound is generated by commercial and recreational vessels, aircraft, sonar, ocean research activities, dredging, construction, offshore mineral exploration, military activities, seismic surveys, and other human activities. These activities occur within the action area to varying degrees throughout the year. ESA-listed species have the potential to be impacted by increased levels of both background sound and high intensity, short-term sounds. Sources of anthropogenic noise are becoming both more pervasive and more powerful, increasing both oceanic background sound levels and peak intensity levels (Hildebrand 2004).

Sounds are often considered to fall into one of two general types: impulsive and non-impulsive, which differ in the potential to cause physical effects to animals (see Southall et al. (2007b) for in-depth discussion). Impulsive sound sources produce brief, broadband signals that are atonal transients and occur as isolated events or repeated in some succession. They are characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures, and generally have an increased capacity to induce physical injury. Non-impulsive sounds can be tonal, narrowband, or broadband, brief or prolonged, and may be either continuous or non-continuous. Some can be transient signals of short duration but without the essential properties of pulses (e.g., rapid rise time). The duration of non-impulsive sounds, as received at a distance, can be greatly extended in a highly reverberant environment.

Anthropogenic sound within the marine environment is recognized as a potential stressor that can harm marine animals and significantly interfere with their normal activities (NRC 2005). The species considered in this opinion may be impacted by anthropogenic sound in various ways. Damage to marine mammal hearing and mass stranding events due to high-intensity sound exposure has been documented (Hildebrand 2004). Anthropogenic sounds may also produce a behavioral response including, but not limited to, changes in habitat to avoid areas of higher sound levels, changes in diving behavior, or (for cetaceans) changes in vocalization (MMC 2007). Many researchers have described behavioral responses of marine mammals to the sounds produced by boats and vessels, as well as other sound sources such as helicopters and fixed-wing aircraft, dredging and construction. Most observations have been limited to short-term behavioral responses, which included temporary cessation of feeding, resting, or social interactions. However, habitat abandonment can lead to more long-term effects, which may have implications at the population level. Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Francis 2013). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson 1995). Masking can reduce the range of communication, particularly long-range communication, such as that for blue and fin whales. Recent scientific evidence suggests that marine mammals, including blue and fin whales, compensate for masking by changing the frequency, source level, redundancy, or timing of their signals, but the long-term implications of these adjustments are currently unknown (Mcdonald et al. 2006a; Parks 2003; Parks 2009).

There are limited data on the hearing abilities of sea turtles, their uses of sounds, and their vulnerability to sound exposure. The functional morphology of the sea turtle ear is poorly understood and debated. Some evidence suggests that sea turtles are able to detect (Bartol and Ketten 2006a; Bartol et al. 1999a; Martin et al. 2012a; Ridgway et al. 1969a) and behaviorally respond to acoustic stimuli (DeRuiter and Doukara 2012; McCauley et al. 2000b; Moein et al. 1995; O'Hara and Wilcox 1990b). Sea turtles may use sound for navigation, locating prey, avoiding predators, and general environmental awareness (Dow Piniak et al. 2012a).

For fishes, the effects of anthropogenic sound have been well documented. However, due to the sheer diversity and numbers of fish, much remains unknown about fishes' abilities to detect and respond to sound. Sensitivity to sound also varies among fishes, and many fish species have developed sensory mechanisms that enable them to detect, localize, and interpret sounds in their environment. When considering the effects of anthropogenic sound on fishes, it is those sound sources that have the potential to cause physical injury and mortality to the individual or disrupt essential behavioral patterns; and whether or not these effects pose a risk to the population of a particular species that are a great concern. These would be acute or limited in duration sound exposures such as those sounds generated during construction activities, use of explosives, and seismic surveys. However, chronic and continuous sound sources such as those produced from vessels or alternative energy sources are also a concern, especially if they could result in fitness consequences and decrease survival and recovery of fishes. Thus, understanding of how fishes detect and respond to sound needs to be tied to ecologically relevant factors such as fish physiology and specific life stage needs, in conjunction with spatial patterns and distribution within the habitats they occupy.

Despite the potential impacts on individual ESA-listed marine mammals, sea turtles, and fishes information is not currently available to determine the potential population level effects of cumulative anthropogenic sound sources in the marine environment (MMC 2007). For example, we currently lack empirical data on how sound impacts growth, survival, reproduction, and vital rates, nor do we understand the relative influence of such effects on the population being considered. As a result, the consequences of anthropogenic sound on ESA-listed marine mammals, sea turtles and fishes at the population or species scale remain uncertain.

This section is divided into subsections addressing the impacts of anthropogenic sound from the following major sources: vessels and commercial shipping; seismic surveys; military activities; active sonar; explosions; and pile driving and construction.

8.3.1 Vessel Sound and Commercial Shipping

Much of the increase in sound in the ocean environment over the past several decades is due to increased shipping, as vessels become more numerous and of larger tonnage (Hildebrand 2009c; Mckenna et al. 2012a; NRC 2003b). Shipping constitutes a major source of low-frequency sound in the ocean (Hildebrand 2004), particularly in the Northern Hemisphere where the majority of vessel traffic occurs. The northeastern U.S. hosts some of the busiest commercial shipping lanes in the world, including those leading into Boston, Providence, Newark, and New York. While commercial shipping vessels contribute a large portion of oceanic anthropogenic noise, other sources of maritime traffic can be present in large numbers and impact the marine environment. These include recreational boats, whale-watching boats, research vessels, and ships associated with oil and gas activities. Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Sound levels are typically higher for the larger and faster vessels. Peak spectral levels for individual commercial vessels are in the frequency band of ten to 50 Hz and range from 195 dB re: μPa^2-s at 1 m for fast-moving (greater than 20 knots) supertankers to 140 dB re: μPa^2-s at 1 m for smaller vessels (NRC 2003b). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above two kHz, which may interfere with important biological functions of cetaceans (Holt 2008b). At frequencies below 300 Hz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013).

8.3.2 Seismic Surveys

Offshore seismic surveys involve the use of high energy sound sources operated in the water column to probe below the seafloor for oil and gas exploration. The Bureau of Ocean Energy Management (BOEM) has issued permits for over 12,000 seismic surveys (2-dimensional and 3-dimensional) in the Gulf of Mexico since the 1953 passage of the Outer Continental Shelf Lands Act and has consulted with NMFS under the ESA on seismic survey permits for oil and gas exploration off the Atlantic coast. Seismic surveys are also used for scientific research, to identify possible seafloor or shallow-depth geologic hazards, and to locate potential archaeological resources and benthic habitats that should be avoided.

Two major categories of seismic surveys conducted within the action area are: (1) deep seismic surveys which include ocean bottom, vertical seismic profile or borehole, 2-dimensional, 3-dimensional, 4-dimensional and wide azimuth surveys, and (2) high resolution surveys. Deep seismic survey acoustic sources consist of air gun arrays while receiver arrays consist of hydrophones or geophones encased in plastic tubing called streamers. When an air gun array fires, an acoustic energy pulse is emitted and reflected or refracted back from the seafloor. These reflected/refracted acoustic signals create pressure fluctuations, which are detected and recorded by the streamers. Seismic air guns generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of 10 to 20 seconds for extended periods (NRC 2003a). Most of the energy from air guns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from air guns usually reach 235 to 240 decibels at dominant frequencies of five to 300 Hz (NRC 2003a). High-resolution surveys collect data on surface and near-surface geology used to identify archaeological sites, potential shallow geologic and manmade hazards for engineering, and site planning for bottom-founded structures. High-resolution surveys may use air guns but also use other sound sources such as sub-bottom profilers (at 2.5-7 kHz), echosounders (single-beam at 12-240 kHz; multibeam at 50-400 kHz), boomers (at 300-3,000 Hz), sparkers (at 50-4,000 Hz), compressed high intensity radar pulse (CHIRP) sub-bottom profiler (at 4-24 kHz), pingers (at 2 kHz), and side-scan sonars (16-1,500 kHz). These sound sources are typically powered either mechanically or electromagnetically.

A study of ambient sound in the North Atlantic showed that air gun activity contributes significantly to ocean sound levels and can appear to be more continuous than other impulsive sounds because of the reverberation from the surface and seabed (Nieukirk et al. 2004). Exposure of cetaceans to very strong impulsive sound sources from air gun arrays can result in auditory damage, such as changes to sensory hairs in the inner ear, which may temporarily or permanently impair hearing by decreasing the range of sound an animal can detect within its normal hearing ranges (reviewed in Finneran 2015). A temporary threshold shift (TTS) results in a temporary change to hearing sensitivity, and the impairment can last minutes to days, but full recovery of hearing sensitivity is expected. At higher received levels, particularly in frequency ranges where animals are more sensitive, PTS can occur, meaning lost auditory sensitivity is unrecoverable. Either of these conditions can result from exposure to a single pulse or from the accumulation of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect. Since there is frequency overlap between air gun array sounds and vocalizations of ESA-listed cetaceans, particularly baleen whales and to some extent sperm whales, seismic surveys could mask these calls at some of the lower frequencies for these species.

ESA-listed cetaceans are expected to exhibit a wide range of behavioral responses as a consequence of being exposed to seismic air gun sound fields and echosounders. Baleen whales are expected to mostly exhibit avoidance behavior, and may also alter their vocalizations. Sperm whales are expected to exhibit less overt behavioral changes, but may alter foraging behavior, including vocalizations. These responses are expected to be temporary with behavior returning to a baseline state shortly after the seismic source becomes in active of leaves the area. Individual whales exposed to sound fields generated by seismic air guns could also exhibit responses not readily observable, such as stress (Romano et al. 2002), that may have adverse effects. Other possible responses to impulsive sound sources like seismic air guns include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007d; Tal et al. 2015; Zimmer and Tyack 2007), but similar to stress, these effects are not readily observable.

As with cetaceans, ESA-listed sea turtles may exhibit a variety of different responses to sound fields associated with seismic air guns and echosounders. Avoidance behavior and physiological responses from air gun exposure may affect the natural behaviors of sea turtles (McCauley et al. 2000b). McCauley et al. (2000b) conducted trials with caged sea turtles and an approaching-departing single air gun to gauge behavioral responses of green and loggerhead sea turtles. Their findings showed behavioral responses to an approaching air gun array at 166 dB re: one micro Pascal rms and avoidance around 175 dB re: 1 micro Pascal rms. From measurements of a seismic vessel operating 3-dimensional air gun arrays in 100 to 120 m water depth this corresponds to behavioral changes at around two kilometers and avoidance around one kilometer.

8.3.3 Ongoing Military Training and Testing Activities

As described in Section 3, the Navy conducts training, testing, and other military readiness activities on range complexes throughout coastal and offshore areas of the action area. Activities are conducted off the Atlantic coast and in the Gulf of Mexico, and in the high seas. The majority of the training and testing activities the Navy conducts in the action area and proposes to continue to conduct are similar, if not identical, to activities that have been occurring in the same locations for decades. For this reason, ongoing U.S. Navy training and testing activities in the action area are mentioned here as part of the baseline.

During training, existing and established weapon systems and tactics are used in realistic situations to simulate and prepare for combat. Activities include routine gunnery, missile, surface fire support, amphibious assault and landing, bombing, sinking, torpedo, tracking, and mine exercises. Testing activities are conducted for different purposes and include at-sea research, development, evaluation, and experimentation. The Navy performs testing activities to ensure that its military forces have the latest technologies and techniques available to them.

Navy activities produce sound and visual disturbances to marine mammals and sea turtles throughout the action area. Anticipated impacts from harassment due to Navy activities include changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Sound produced during Navy training and testing activities is also expected to result in instances of TTS and PTS to marine mammals and sea turtles. The Navy training and testing activities constitute a federal action and these activities have previously undergone section 7 consultations. Through these consultations with NMFS, the Navy has implemented monitoring and conservation measures to reduce the potential effects of underwater sound from military training and testing activities on ESA-listed resources in the Atlantic Ocean and Gulf of Mexico. Conservation measures include employing visual observers and implementing mitigation zones when training and testing using active sonar or explosives.

The Air Force conducts training and testing activities on range complexes on land and in U.S. waters in the action area. Aircraft operations and air-to-surface activities may occur in the action area (e.g., off Florida). Air Force activities generally involve the firing or dropping of munitions (e.g., bombs, missiles, rockets, and gunnery rounds) from aircraft towards targets located on the surface, though Air Force training exercises may also involve boats. These activities have the potential to impact ESA-listed species by physical disturbance, boat strikes, debris, ingestion, and effects from sound and pressure produced by detonations. Air Force training and testing activities constitute a federal action and take of ESA-listed species considered for these Air Force activities have previously undergone separate section 7 consultations.

8.3.4 Active Sonar

Active sonar emits high-intensity acoustic energy and receives reflected and/or scattered energy. A wide range of sonar systems are in use for both civilian and military applications. The primary sonar characteristics that vary with application are the frequency band, signal type (pulsed or continuous), rate of repetition, and source level. Sonar systems can be divided into three categories, depending on their primary frequency of operation; low frequency for one kHz and less, mid frequency for one to 20 kHz, and high frequency for 20 kHz and greater[20] (Hildebrand 2004). Low frequency systems are designed for long-range detection (Popper et al. 2014). Signal transmissions are emitted in patterned sequences that may last for days or weeks. Mid-frequency military sonars include tactical anti-submarine warfare sonars, designed to detect submarines over several tens of kilometers, depth sounders and communication sonars. High-frequency military sonars includes those incorporated into weapons (torpedoes and mines) or weapon countermeasures (mine countermeasures or anti-torpedo devices), as well as sidescan sonar for seafloor mapping. Commercial sonars are designed for fish finding, depth sounding, and sub-bottom profiling. They typically generate sound at frequencies of 3 to 200 kHz, with source levels ranging from 150-235 dB re 1μPa @ 1 m (Hildebrand 2004). Depth sounders and sub-bottom profilers are operated primarily in nearshore and shallow environments; however, fish finders are operated in both deep and shallow areas.

8.3.5 Underwater Explosions

BOEM requires that oil and gas structures must be removed from the sea floor within one year of lease termination. Many of these structures are removed by explosively severing the underwater supportive elements, which produces a shock wave that kills, injures, or disrupts marine life in the blast radius (Gitschlag et al. 1997). An underwater explosion is composed of an initial shock

[20] Note that the classification of active sonar sources by frequency (i.e., low, mid, high) can vary.

wave, followed by a succession of oscillating bubble pulses. A shock wave is a compression wave that expands radially out from the detonation point of an explosion. The direct shock wave results in the peak shock pressure (compression) and the reflected wave at the air-water surface produces negative pressure (expansion). Explosions are described by metrics such as amplitude, energy and time-space characteristics of the pressure wave (Popper et al. 2014). In the case of detonations, the pressure wave is very pronounced from the sudden release of high energy, and the resulting shock wave can result in injury or death of animals closest to the site. The amount of explosives used is the primary factor affecting how large an area is impacted, but extent of impacts is also affected by the depth of the charge, type of explosive, and whether bulk or shape charges are used.

Impacts of underwater explosives on whales, sea turtles and fishes could include death, injuries to internal organs, auditory damage, physical discomfort, and behavioral disruptions. There is considerable variability in the effects of explosive blasts on fish species; research suggests that there is far more damage to fish species with swim bladders than to species lacking these air chambers (Hastings and Popper 2005a). Lethal injuries result from massive trauma or combined trauma to internal organs as a result of close proximity to the point of detonation. Types of lethal injuries include massive lung hemorrhage, gastrointestinal tract injuries (contusions, ulcerations, and ruptures), and concussive brain damage, cranial and skeletal (shell) fractures, hemorrhage, or massive inner ear trauma (Ketten 1995). Examples of nonlethal injuries include eardrum rupture, bruising, and immobilization of severely stunned animals. Stunned animals beneath the water may drown or become vulnerable to other impacts while they are immobilized. Delayed complications arising from nonlethal injuries may ultimately result in the death of the animal because of increased risks from secondary infection, predation, or disease.

8.3.6 Pile Driving and Construction Sound

Industrial activities and construction both in the ocean and along the shoreline can contribute to underwater noise. Pile driving is commonly used for the construction of foundations for a large number of structures including bridges, buildings, retaining walls, harbor facilities, offshore wind turbines, and offshore structures for the oil and gas industry. Pile driving during construction activities is of special concern because it generates noise with a very high source level. During pile installation, noise is produced when the energy from construction equipment is transferred to the pile and released as pressure waves into the surrounding water and sediments. The impulsive sounds generated by impact pile driving are characterized by a relatively rapid rise time to a maximal pressure value followed by a decay period that may include a period of diminishing, oscillating maximal and minimal pressures (Illingworth and Rodkin 2001; Illingworth and Rodkin 2007; Reyff 2012). The amount of noise produced by pile driving depends on a variety of factors, including the type and size of the impact hammer, size of the pile, the properties of the sea floor, and the depth of the water. The predominant energy in pile impact impulses is at frequencies below approximately 2000 Hz with most occurring below 1000 Hz (Laughlin 2006; Reyff 2008; Reyff 2012). Pressure levels from 190-220 dB re 1 μPa were reported for piles of different sizes in a number of studies (NMFS 2006a). The majority of the sound energy associated with pile driving is in the low frequency range (<1,000 Hz) (Illingworth and Rodkin Inc. 2001; Illingworth and Rodkin Inc. 2004; Reyff 2003). Impact pile driving occurs over small spatial and temporal scales and produces high-intensity, low-frequency, impulsive sounds with high peak pressures that can be detected by mammals, sea turtles and other marine species (Dow Piniak et al. 2012a). The expected type of injury to sea turtles and marine mammals is caused by pressure wave damage to hair cells, ear canals, or ear drums as these structures compress and expand with passage of the wave. Vibratory pile driving produces a continuous sound with peak pressures lower than those observed in impulses generated by impact pile driving (Popper et al. 2014).

8.4 Dredging

Nearshore and offshore coastal areas are often dredged to support commercial shipping, recreational boating, construction of infrastructure, and marine mining. Dredging operations have the potential to emit sounds at levels that could disturb individuals of many taxa. Depending on the type of dredge, peak sound pressure levels from 100 to 140 dB re 1 μPa were reported in one study (Clarke et al. 2003). As with pile driving, most of the sound energy associated with dredging is in the low-frequency range, <1000 Hz (Clarke et al. 2003). In addition to disturbance from sounds, hydraulic dredging can directly harm large marine animals (e.g., sturgeon and sea turtles) by lethally entraining them through the dredge drag-arms and impeller pumps. Large animals that are entrained in hydraulic dredges rarely survive the encounter. Hopper dredges, in particular, are capable of moving relatively quickly compared to turtles and fish which can be overtaken and entrained by the suction draghead of the advancing dredge. An estimated 609 incidental takes (lethal or sublethal interactions) of sea turtles were documented from hopper dredging activity in the southeastern U.S. from 1980 through 2006 (Dickerson et al. 2007). Dickerson (2006) reported 15 Atlantic sturgeon taken in dredging activities conducted by the United States Army Corps of Engineers from 1990 to 2010, most captured by hopper dredge. Notably, these reports include only those trips when an observer was on board to document capture.

Reductions in dredge entrainment rates for sea turtles have been achieved through mitigation measures including gear modifications, operational changes, time-area restrictions, and the capture and relocation of turtles away from dredge sites (Dickerson et al. 2007). Dickerson et al. (2007) studied the effectiveness of turtle relocation trawling in reducing the incidental take of sea turtles in hopper dredge operations. They found that relocation trawling can be an effective management option provided that a substantial amount of trawling effort is conducted either at the onset of dredging or early in the project.

Dredging can also indirectly affect marine species through habitat modification, changes in prey availability, and water quality degradation, including changes in dissolved oxygen and salinity gradients (Campbell and Goodman 2004; Jenkins et al. 1993; Secor and Niklitschek 2001). Dredging and filling operations can impact important sturgeon habitat features by disturbing benthic fauna, eliminating deep holes, and altering rock substrates (Smith and Clugston 1997). As benthic omnivores, sturgeon are particularly sensitive to modifications of the benthos that affect the quality, quantity and availability of prey species. Hatin et al. (2007) reported avoidance behavior by Atlantic sturgeon during dredging operations and McQuinn and Nellis (2007) found that Atlantic sturgeon were substrate dependent and avoided dredge spoil dumping grounds.

8.5 Pollution

Below we discuss the effects of oil pollution, contaminants and pesticides, nutrient loading and algal blooms, and marine debris in the action area.

8.5.1 Oil Pollution

The Gulf of Mexico portion of the action area is an area of high-density offshore oil extraction with chronic, low-level spills and occasional massive spills. Oil spills remain a significant threat to marine ecosystems in the Gulf of Mexico due to the large amount of extraction and refining activity in the region. There are approximately 4,000 oil and gas structures in the northern Gulf of Mexico, 90 percent of which are off Louisiana and Texas (USN 2009).

The largest spill within the action area occurred in April of 2010 as a result of a fire and explosion aboard the semisubmersible drilling platform Deepwater Horizon roughly 80 km southeast of the Mississippi Delta (NOAA 2010a). Once the platform sank, the riser pipe connecting the platform to the wellhead on the seafloor broke in multiple locations, initiating an uncontrolled release of oil from the exploratory well. Over the next three months, oil was released into the Gulf of Mexico, resulting in oiled regions of Texas, Louisiana, Mississippi, Alabama, and Florida and widespread oil slicks throughout the northern Gulf of Mexico that closed more than one-third of the Gulf of Mexico Exclusive Economic Zone to fishing due to contamination concerns. Apart from the widespread surface slick, massive undersea oil plumes formed, possibly through the widespread use of dispersants, and reports of tarballs washing ashore throughout the region were common. NOAA has estimated that 4.9 million barrels of oil were released (Lubchenco et al. 2010).

Oil released into the marine environment contains aromatic organic chemicals known to be toxic to a variety of marine life (Yender et al. 2002). Oil spills can impact wildlife directly through three primary pathways: (1) ingestion—when animals swallow oil particles directly or consume prey items that have been exposed to oil, (2) absorption—when animals come into direct contact with oil, and (3) inhalation—when animals breathe volatile organics released from oil or from "dispersants" applied by response teams in an effort to increase the rate of degradation of the oil in seawater. Direct exposure to oil can cause acute damage including skin, eye, and respiratory irritation, reduced respiration, burns to mucous membranes such as the mouth and eyes, diarrhea, gastrointestinal ulcers and bleeding, poor digestion, anemia, reduced immune response, damage to kidneys or liver, cessation of salt gland function, reproductive failure, and death (NOAA 2003; NOAA 2010b; Vargo et al. 1986c; Vargo et al. 1986a; Vargo et al. 1986b). Nearshore spills or large offshore spills that reach shore can oil beaches on which sea turtles lay their eggs, causing birth defects or mortality in the nests (NOAA 2003; NOAA 2010b). Disruption of other essential behaviors, such as breeding, communication, and feeding may also occur. The loss of invertebrate communities due to oiling or oil toxicity would also decrease prey availability for hawksbill, Kemp's ridley, and loggerhead sea turtles (NOAA 2003). Sea turtles species which commonly forage on crustaceans and mollusks may be vulnerable to oil ingestion due to oil adhering to the shells of these prey and the tendency for these organisms to bioaccumulate toxins found in oil (NOAA 2003). Seagrass beds may be particularly susceptible to oiling as oil contacts grass blades and sticks to them, hampering photosynthesis and gas exchange (Wolfe et al. 1988). If spill cleanup is attempted, mechanical damage to seagrass can result in further injury and long-term scarring. Loss of seagrass due to oiling would be important to green sea turtles, as this is a significant component of their diets (NOAA 2003). Sea turtles are known to ingest and attempt to ingest tar balls, which can block their digestive systems, impairing foraging or digestion and potentially causing death (NOAA 2003).

8.5.2 Contaminants and Pesticides

Coastal habitats are often in close proximity to major sources of pollutants and contaminants, which make their way into the marine environment from industrial, domestic and agricultural sources. Sources include wastewater treatment plants, septic systems, industrial facilities, agriculture, animal feeding operations, and improper refuse disposal. Agricultural discharges, as well as discharges from large urban centers, contribute contaminants as well as coliform bacteria to coastal watersheds. Contaminants can be carried long distances from terrestrial or nearshore sources and ultimately accumulate in offshore pelagic environments (USCOP 2004). For example, the Gulf of Mexico portion of the action area is a major sink for pollution from a variety of marine and terrestrial sources, which ultimately can interfere with ecosystem health and particularly that of ESA-listed species and their habitats. The Mississippi River drains 80 percent of the U.S. cropland (including the fertilizers, pesticides, herbicides, and other contaminants that are applied to it) and discharges into the Gulf of Mexico (MMS 1998).

Chemical contaminants, particularly those that are persistent in the environment, are a particular concern for marine animals that often occupy high trophic positions. Persistent organic pollutants, which include legacy pesticides (e.g., dichlorodiphenyltrichloroethane [DDT], chlordane), legacy industrial-use chemicals (e.g., polychlorinated biphenyls), and emerging contaminants of concern (e.g., polybrominated diphenyl ethers, perfluorinated compounds) accumulate in fatty tissues of marine organisms and are magnified through the food chain, leading upper trophic predators to be highly exposed (National Academies of Sciences and Medicine 2016). High concentrations of polychlorinated biphenyls (PCBs) and DDT have been reported in tissues of marine mammals in most parts of the world, particularly in coastal regions adjacent to heavy coastal development and/or industry. These legacy persistent organic pollutants have been linked to a number of adverse health effects including endocrine disruption, reproductive impairment or developmental effects, and immune dysfunction or disease susceptibility (National Academies of Sciences and Medicine 2016). Polybrominated diphenyl ethers commonly used as flame retardants, are another class of persistent organic pollutants that have spread globally in the environment and have also been reported in a broad array of marine mammal species (National Academies of Sciences and Medicine 2016).

Polycyclic aromatic hydrocarbons represent another group of organic compounds that can result in adverse effects on marine species. Anthropogenic sources of polycyclic aromatic hydrocarbons include crude oil (see Oil Pollution above), fumes, vehicle exhaust, coal, organic solvents, and wildfires. Exposure may be continual, associated with run-off from impervious cover in developed coastal regions, or natural seeps that produce low-level but steady exposure. Acute events such as oil spills may produce pulses of more significant exposure. Depending on the route of exposure (inhalation/aspiration, ingestion, direct dermal contact), polycyclic aromatic hydrocarbons can produce a broad range of health effects including lung disease, disruption of the hypothalamicpituitary-adrenal axis, and altered immune response (National Academies of Sciences and Medicine 2016). Although polycyclic aromatic hydrocarbons are more rapidly metabolized and do not accumulate as is the case with persistent organic pollutants, the toxic effects (lung disease, hypothalamicpituitary-adrenal axis damage) may be long-lasting and initiate chronic disease conditions.

North Atlantic right whales, as with many marine mammals, are exposed to numerous toxins in their environment, many of which are introduced by humans. Levels of chromium in North Atlantic right whale tissues are sufficient to be mutagenic and cause cell death in lung, skin, or testicular cells and are a concern for the species' recovery (Chen et al. 2009; Wise et al. 2008). The organochlorines DDT, dichlorodiphenyldichloroethylene, PCBs, dieldrin, chlordane, hexachlorobenzene, and heptachlor epoxide have been isolated from blubber samples and reported concentrations may underestimate actual levels (Woodley et al. 1991). Mean PCB levels in North Atlantic right whales are greater than any other baleen whale species thus far measured, although less than one-quarter of the levels measured in harbor porpoises (Gauthier et al. 1997; Van Scheppingen et al. 1996). Flame retardants such as polybrominated diphenyl ethers (known to be carcinogenic) have also been measured in North Atlantic right whales (Montie et al. 2010).

A variety of heavy metals have been found in sea turtles tissues in levels that increase with turtle size. These include arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc, (Barbieri 2009; Fujihara et al. 2003; García-Fernández et al. 2009; Godley et al. 1999; Storelli et al. 2008). Cadmium has been found in leatherbacks at the highest concentration compared to any other marine vertebrate (Gordon et al. 1998). Newly emerged hatchlings have higher concentrations than are present when laid, suggesting that metals may be accumulated during incubation from surrounding sands (Sahoo et al. 1996). Arsenic has been found to be very high in green turtle eggs (Van de Merwe et al. 2009). Sea turtle tissues have been found to contain organochlorines, including chlorobiphenyl, chlordane, lindane, endrin, endosulfan, dieldrin, perfluorooctane sulfonate, perfluorooctanoic acid, DDT, and PCB (Alava et al. 2006; Gardner et al. 2003; Keller et al. 2005; Oros et al. 2009; Storelli et al. 2007). PCB concentrations are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (Davenport et al. 1990; Oros et al. 2009). Levels of PCBs found in green sea turtle eggs are considered far higher than what is fit for human consumption (Van de Merwe et al. 2009).

Several studies have reported correlations between organochlorine concentration level and indicators of sea turtle health or fitness. Organochlorines have the potential to suppress the immune system of loggerhead sea turtles and may affect metabolic regulation (Keller et al. 2006; Oros et al. 2009). Accumulation of these contaminants can also lead to deficiencies in endocrine, developmental and reproductive health (Storelli et al. 2007). Balazs (1991) suggested that environmental contaminants are a possible factor contributing to the development of the viral disease Fibropapillomatosis in sea turtles by reducing immune function. Day et al. (2007) investigated mercury toxicity in loggerhead sea turtles by examining trends between blood mercury concentrations and various health parameters. They concluded that subtle negative impacts of mercury on sea turtle immune function are possible at concentrations observed in the wild. Keller et al. (2004) investigated the possible health effects of organochlorine contaminants, such as PCBs and pesticides on loggerhead sea turtles. Although concentrations were relatively low compared with other species, they found significant correlations between organochlorine contaminants levels and health indicators for a wide variety of biologic functions, including immunity and homeostasis of proteins, carbohydrates, and ions.

The life histories of sturgeon species (i.e., long lifespan, extended residence in estuarine habitats, benthic foraging) predispose them to long-term, repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants (Dadswell 1979). Heavy metals and organochlorine compounds accumulate in sturgeon tissue, but their long-term effects are not well studied (Ruelle and Keenlyne 1993). Shortnose sturgeon collected from the Delaware and Kennebec Rivers had total toxicity equivalent concentrations of polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, PCBs, dichlorodiphenyldichloroethylene, aluminum, cadmium, and copper all above adverse effect concentration levels reported in the literature (Brundage III 2008). Dioxin and furans were detected in ovarian tissue from shortnose sturgeon caught in the Sampit River/Winyah Bay system (South Carolina).

High levels of contaminants, including chlorinated hydrocarbons, in several other fish species are associated with reproductive impairment (Billsson 1998; Cameron et al. 1992; Giesy et al. 1986; Hammerschmidt et al. 2002), reduced survival of larval fish (McCauley et al. 2015; Willford et al. 1981), delayed maturity and posterior malformations (Billsson 1998). Pesticide exposure in fish may affect anti-predator and homing behavior, reproductive function, physiological maturity, swimming speed, and distance (Beauvais et al. 2000; Scholz et al. 2000; Waring and Moore 2004). Sensitivity to environmental contaminants also varies by life stage. Early life stages of fish appear to be more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976). Early life stage Atlantic and shortnose sturgeon are vulnerable to PCB and Tetrachlorodibenzo-p-dioxin toxicities of less than 0.1 parts per billion (Chambers et al. 2012). Increased doses of PCBs and Tetrachlorodibenzo-p-dioxin have been correlated with reduced physical development of Atlantic sturgeon larvae, including reductions in head size, body size, eye development and the quantity of yolk reserves (Chambers et al. 2012). Juvenile shortnose sturgeon raised for 28 days in North Carolina's Roanoke River had a nine percent survival rate compared to a 64 percent survival rate at non-riverine control sites (Cope et al. 2011). The reduced survival rate could not be correlated with contaminants, but significant quantities of retene, a paper mill by-product with dioxin-like effects on early life stage fish, were detected in the river (Cope et al. 2011).

Dwyer et al. (2005) compared the relative sensitivities of common surrogate species used in contaminant studies to 17 ESA-listed species including Atlantic sturgeon. The study examined

96-hour acute water exposures using early life stages where mortality is an endpoint. Chemicals tested were carbaryl, copper, 4-nonphenol, pentachlorophenal and permethrin. Of the ESA-listed species, Atlantic sturgeon were ranked the most sensitive species tested for four of the five chemicals (Atlantic and shortnose sturgeon were found to be equally sensitive to permethrin). Additionally, a study examining the effects of coal tar, a byproduct of the process of destructive distillation of bituminous coal, indicated that components of coal tar are toxic to shortnose sturgeon embryos and larvae in whole sediment flow-through and coal tar elutriate static renewal (Kocan et al. 1993).

Despite the vast evidence to suggest that marine animals are exposed to anthropogenic, as well as natural, chemicals capable of producing significant toxic effects, only a few studies have actually examined the impacts on population survival or reproductive rates. Such observational assessments are inherently challenging due to the difficulty in controlling for confounding or interacting variables, as well as the sublethal but chronic nature of chemical contaminant effects, and the difficulty of observing mortality or reproductive endpoints, particularly in long-lived species such as cetaceans and sea turtles (National Academies of Sciences and Medicine 2016).

8.5.3 Nutrient Loading and Algal Blooms

Industrial and municipal activities can result in the discharge of large quantities of nutrients into coastal waters. Excessive nutrient enrichment results in eutrophication, a condition associated with degraded water quality, algal blooms (including harmful algal blooms), oxygen depletion, loss of seagrass and coral reef habitat, and in some instances the formation of hypoxic “dead zones” (USCOP 2004). Hypoxia (low dissolved oxygen concentration) occurs when waters become overloaded with nutrients such as nitrogen and phosphorus, which enter oceans from agricultural runoff, sewage treatment plants, bilge water, atmospheric deposition, and other sources. An overabundance of nutrients can stimulate algal blooms resulting in a rapid expansion of microscopic algae (phytoplankton). When excess nutrients are consumed, the algae population dies off and the remains are consumed by bacteria. Bacterial consumption decreases the dissolved oxygen level in the water which may result in mortality of fish and crustaceans, reduced benthic and demersal organism abundance, reduced biomass and species richness, and abandonment of habitat to areas that are sufficiently oxygenated (Craig et al. 2001; Rabalais et al. 2002). Higher trophic level species (e.g. turtles and marine mammals) may be impacted by the reduction of available prey as a result of hypoxic conditions. For example, high nutrient loads from the Mississippi River create a massive hypoxic “dead zone” in Northern Gulf of Mexico each year. This hypoxic event occurs annually from as early as February to as late as October, spanning from the Mississippi River Delta to Galveston, Texas. In 2017, NOAA estimated that the Gulf of Mexico Dead Zone covered over 8,000 square miles, an area about the size of New Jersey.

Marine algal toxins are produced by unicellular algae that are often present at low concentrations but that may proliferate to form dense concentrations under certain environmental conditions (National Academies of Sciences and Medicine 2016). When high cell concentrations form, the toxins that they produce can harm marine life, and this is referred to as a harmful algal bloom (HAB). Marine mammals can be exposed to HAB toxins directly by inhalation or indirectly through food web transfer, and these toxins can cause severe neurotoxic effects (Van Dolah 2005). Mortality and morbidity related to HAB toxins have been increasingly reported over the past several decades, and biotoxicosis has been a primary contributor to large scale die-offs across marine mammal taxa (Simeone et al. 2015; Van Dolah 2005). Domoic acid has also been detected in tissues of marine mammals along the southeast U.S. coast (Twiner et al. 2011), but perhaps of greater concern in this area are the brevetoxins produced by Gulf of Mexico red tides. Brevetoxin has been implicated in multiple die-offs involving common bottlenose dolphins, as well as the endangered Florida manatee (Flewelling et al. 2005) (Simeone et al. 2015; Twiner et al. 2012). Capper et al. (2013) found that both turtles and manatees were exposed to multiple HAB toxins (okadaic acid, brevetoxins, saxitoxins, and likely others) in Florida. A recent survey of the peer reviewed literature on marine mammal diseases and reports of marine mammal mass mortality events suggests an increase in the frequency of marine mammal die-offs resulting from exposure to harmful algal blooms over the past 40 years (Gulland and Hall 2007).

8.5.4 Marine Debris

Marine debris has become a widespread threat for a wide range of marine species that are increasingly exposed to it on a global scale. Plastic is the most abundant material type worldwide, accounting for more than 80 percent of all marine debris (Poeta et al. 2017). The most common impacts of marine debris are associated with ingestion or entanglement and both types of interactions can cause the injury or death of animals of many different species. Ingestion occurs when debris items are intentionally or accidentally eaten (e.g. through predation on already contaminated organisms or by filter feeding activity, in the case of large filter feeding marine organisms, such as whales) and enter in the digestive tract. Ingested debris can damage digestive systems and plastic ingestion can also facilitate the transfer of lipophilic chemicals (especially persistent organic pollutants) into the animal's bodies. An estimated 640,000 tons of fishing gear is lost, abandoned, or discarded at sea each year throughout the world's oceans (Macfadyen et al. 2009). These "ghost nets" drift in the ocean and can fish unattended for decades (ghost fishing), killing large numbers of marine animals through entanglement.

Marine debris is a significant concern for ESA-listed species, particularly sea turtles and marine mammals. The initial developmental stages of all turtle species are spent in the open sea. During this time both juvenile turtles and their buoyant food are drawn by advection into fronts (convergences, rips, and driftlines). The same process accumulates large volumes of marine debris, such as plastics and lost fishing gear, in ocean gyres (Carr 1987). An estimated four to twelve million metric tons of plastic enter the oceans annually (Jambeck et al. 2015). It is thought that sea turtles eat plastic because it closely resembles jellyfish, a common natural prey item (Schuyler 2014). Ingestion of plastic debris can block the digestive tract which can cause turtle mortality as well as sub-lethal effects including dietary dilution, reduced fitness, and absorption of toxic compounds (Laist et al. 1999; Lutcavage et al. 1997). Santos et al. (2015) found that a surprisingly small amount of plastic debris was sufficient to block the digestive tract and cause death. They reported that 10.7 percent of green turtles in Brazilian waters were killed by plastic ingestion, while 39.4 percent had ingested enough plastic to have killed them. These results suggest that debris ingestion is a potentially important source of turtle mortality, one that may be masked by other causes of death. Gulko and Eckert (2003) estimated that between one-third and one-half of all sea turtles ingest plastic at some point in their lives. A more recent study by Schuyler et al. (2015) estimates that 52 percent of sea turtles globally have ingested plastic debris. Schuyler et al. (2016) synthesized the factors influencing debris ingestion by turtles into a global risk model, taking into account the area where turtles are likely to live, their life history stage, the distribution of debris, the time scale, and the distance from stranding location. They found that oceanic life stage turtles are at the highest risk of debris ingestion. Based on this model, olive ridley turtles are the most at-risk species; green, loggerhead, and leatherback turtles were also found to be at a high and increasing risk from plastic ingestion (Schuyler 2014). The regions of highest risk to global turtle populations are off the east coasts of the U.S., Australia, and South Africa; the east Indian Ocean, and Southeast Asia. In addition to ingestion risks, sea turtles can also become entangled in marine debris such as fishing nets, monofilament line, and fish-aggregating devices (Laist et al. 1999; Lutcavage et al. 1997; NRC 1990b). Turtles are particularly vulnerable to ghost nets due to their tendency to use floating objects for shelter and as foraging stations (Dagorn et al. 2013; Kiessling 2003).

Marine mammals are also particularly susceptible to the threats associated with marine debris and many cases of ingestion and entanglement have been reported around the world (Poeta et al. 2017). Baulch and Perry (2014) found that the proportion of cetacean species ingesting debris or becoming entangled in debris is increasing. Based on stranding data, they found that recorded rates of ingestion have increased by a factor of 1.9 and rates of entanglement have increased by a factor of 6.5 over the last forty years (1970-2010). Ingestion of marine debris can also have fatal consequences for large whales. For example in 2008, two male sperm whales stranded along the northern California coast with large amounts of fishing net scraps, rope, and other plastic debris in their stomachs. One animal had a ruptured stomach, the other was emaciated, and gastric impaction was suspected as the cause of both deaths (Jacobsen et al. 2010). de Stephanis et al. (2013) also describe a case of mortality of a sperm whale related to the ingestion of large amounts of marine debris in the Mediterranean Sea.

Marine debris may also impact coral reef ecosystems. For example, Chiappone et al. (2002) conducted surveys of the Florida Keys and documented marine debris entanglement in reef areas. The authors documented damage from marine debris on coral reef habitat, including damage to scleractinian corals (likely inclusive of ESA-listed corals such as elkhorn and staghorn coral).

8.6 Liquefied Natural Gas Facilities

Natural gas is chilled to approximately -260 °F (-162.2 ºC) into liquid form for transportation overseas. The liquefied natural gas (LNG) is loaded onto tankers and upon arrival in the United States is converted back into a gas for distribution via pipeline. LNG is re-gasified by circulating water (or some other fluid) through a radiator-like system that warms LNG to vaporization temperatures. LNG facilities use either a closed-loop or open-loop system to convert the liquid into gas. Open-loop systems require a continuous stream of water in order to warm LNG (100-200 million gallons per day), usually withdrawn directly from the river system or ocean in which the terminal is sited. Eggs, larvae, and other organisms in the water column can be impinged or entrained as water is withdrawn from the source to the terminal. Once the LNG is vaporized, the seawater used in cooling is either discharged back into the environment or utilized again through the cooling loop. The discharge can be at temperatures significantly different from ambient. Potential stressors to ESA-listed species associated with the construction and operation of LNG facilities include increased dredging activities to allow for the passage and berthing of LNG vessels, pile driving for pier and berth construction, increased risk of ship strikes due to vessel traffic, potential early life stage losses from ballast water and facility intakes, loss of habitat due to water withdrawal, and increased ambient water temperature from discharged water.

Existing LNG import terminals within the action area are located in Saint John (New Brunswick), Everett (Massachusetts), Cove Point (Maryland), Elba Island/Savannah (Georgia), and two offshore of Gloucester (Massachusetts). Two LNG export terminals are currently under construction (Cove Point, Maryland and Elbas Island, Georgia) and LNG terminals have been proposed for offshore from Long Island, New York and Jacksonville, Florida (Federal Energy Regulatory Commission website accessed January 26, 2017: https://www.ferc.gov/industries/gas/indus-act/lng.asp). Demand for LNG is predicted to increase, and there are several proposals to build new or expand existing LNG facilities within the action area (Federal Energy Regulatory Commission website accessed January 26, 2017: https://www.ferc.gov/industries/gas/indus-act/lng.asp).

8.7 Whaling

Whale populations within the action area have historically been impacted by aboriginal subsistence hunting, small-scale commercial whaling and, more recently, large-scale commercial whaling using factory ships. From 1864 through 1985, at least 2,400,000 baleen whales (excluding minke whales) and sperm whales were killed (Gambell 1999). Many of the whaling numbers reported in the 20th century likely represent minimum estimates, as illegal or underreported catches are not included. For example, recently uncovered Union of Soviet Socialists Republics catch records indicate extensive illegal whaling activity between 1948 and 1979 (Ivashchenko et al. 2014).

Prior to current prohibitions on whaling most large whale species were significantly depleted to the extent it was necessary to list them as endangered under the Endangered Species Preservation Act of 1966. Since the end of large-scale commercial whaling, the primary threat to these species has been eliminated, although many whale species have not yet fully recovered from those historic declines.

In 1982, the International Whaling Commission issued a moratorium on commercial whaling, which went into effect in 1986. There is currently no legal commercial whaling by International Whaling Commission Member Nations party to the moratorium; however, whales are still killed commercially by countries that filed objections to the moratorium. Presently three types of whaling take place: (1) aboriginal subsistence whaling to support the needs of indigenous people; (2) special permit whaling; and (3) commercial whaling conducted either under objection or reservation to the IWC moratorium (i.e., Iceland and Norway). Some of the whales killed in these fisheries are likely part of the same population of whales occurring within the action area for this consultation.

Under current International Whaling Commission regulations, aboriginal subsistence whaling is permitted for Denmark (Greenland, fin and minke whales, *Balaenoptera* sp.), the Russian Federation (Siberia, gray, *Eschrichtius robustus*, and bowhead, *Balaena mysticetus*, whales), St. Vincent and the Grenadines (Bequia, humpback whales, *Megaptera novaeangliae*) and the U.S. (Alaska, bowhead and gray whales). It is the responsibility of national governments to provide the International Whaling Commission with evidence of the cultural and subsistence needs of their people. The Scientific Committee provides scientific advice on safe catch limits for such stocks (IWC 2012). Based on the information on need and scientific advice, the International Whaling Commission then sets catch limits, recently in five-year blocks.

Norway and Iceland establish their own catch limits but must provide information on those catches and associated scientific data to the International Whaling Commission. Norway takes minke whales in the North Atlantic Ocean within its Exclusive Economic Zone, and Iceland takes minke whales and fin whales in the North Atlantic Ocean, within its Exclusive Economic Zone (IWC 2012). The Russian Federation has also registered an objection to the moratorium decision but does not exercise it. The Japanese whaling fleet carries out whale hunts under the guise of "scientific research," though very few peer-reviewed papers have been published as a result of the program, and meat from the whales killed under the program is processed and sold at fish markets.

8.8 Fisheries Bycatch

In this section, we summarize the best available information on fisheries bycatch of ESA-listed species in the action area.

8.8.1 Bycatch of Sea Turtles

Bycatch of ESA-listed sea turtles occurs in a diversity of fisheries throughout the broad geographic oceanic ranges of these species. Sea turtle bycatch occurs in both large-scale commercial fishing operations as well as small-scale, artisanal fisheries throughout the world. Fishing gears that are known to interact with sea turtles include trawls, longlines, purse seines, gillnets, pound nets, dredges and to a lesser extent, pots and traps (Finkbeiner et al. 2011; Lewison et al. 2013). Sea turtle bycatch rates (i.e., individuals captured per unit of fishing effort) and mortality rates (i.e., individuals killed per number captured) can vary widely both within and across particular fisheries due to a combination of factors. These include gear types and gear configurations, fishing methods (e.g., depth fished, soak times), fishing locations, fishing seasons, time fished (i.e., day versus night), and turtle handling and release techniques used (Lewison et al. 2013; Wallace et al. 2010). Entanglement in fishing gear and/or plastics can result in severe ulcerative dermatitis, and amputation of flippers (Orós et al. 2005). If mortality is not directly observed during gear retrieval, it may occur after the turtle is released due to physiological stress and injury suffered during capture. Recent studies indicate that underwater entrapment in fishing gear (i.e., trawls and gillnets) followed by rapid decompression when gear is brought to the surface may cause gas bubble formation within the blood stream (i.e., embolism) and tissues leading to organ injury, impairment, and even post-release mortality in some bycaught turtles (Fahlman et al. 2017; Garcia-Parraga et al. 2014).

The primary turtle species captured in U.S. fisheries in Atlantic and Gulf of Mexico fisheries is the loggerhead (Moore et al. 2009a). The southeastern U.S. comprises one of the largest aggregate nesting rookeries for loggerhead sea turtles in the world, and the continental shelf provides critical ontogenetic habitats for this population. Thus, because a large number of individuals are present throughout areas of high fishing activity, loggerheads interact with a greater number of fishing fleets and gear types in the Atlantic than other sea turtle species (Moore et al. 2009a).

The Southeast shrimp trawl fishery in the Atlantic and Gulf of Mexico has historically accounted for the overwhelming majority (up to 98 percent) of sea turtle bycatch in U.S. fisheries (Finkbeiner et al. 2011). Regulations that went into effect in the early 1990's require shrimp trawlers in the Atlantic and Gulf of Mexico to modify their gear with turtle excluder devices (TEDs) designed to allow turtles to escape trawl nets and avoid drowning. Analyses by Epperly and Teas (2002) indicated that, while early versions of TEDs were effective for some species, the minimum requirements for the escape opening dimension were too small for larger sea turtles, particularly loggerheads and leatherbacks. NMFS implemented revisions to the TED regulations in 2003 to address this issue (68 FR 8456, February 21, 2003). The revised TED regulations were estimated to reduce shrimp trawl related mortality by 94 percent for loggerheads and 97 percent for leatherbacks (NMFS 2014c). Finkbeiner et al. (2011) compared sea turtle bycatch estimated before and after the 2003 TED enlargement regulations. In the late 1990's, the southeast shrimp trawl fishery resulted in an estimated 340,500 sea turtle interactions and 133,400 mortalities. By comparison, by 2007 this fishery resulted in an estimated 69,300 interactions and 3,700 mortalities (Finkbeiner et al. 2011). The decline in sea turtle bycatch over this period can be attributed to a combination of the revised TED regulations and a significant decrease in fishing effort. Time-area closures have also been implemented to reduce sea turtle bycatch in shrimp trawl fisheries operating in particularly sensitive areas.

Although mitigation measures have greatly reduced the impact on sea turtle populations, the shrimp trawl fishery is still responsible for large numbers of turtle mortalities each year. The Gulf of Mexico fleet accounts for a large percentage of the sea turtle bycatch in this fishery. In 2010, the Gulf of Mexico shrimp trawl fishery had an estimated bycatch mortality of 5,166 turtles (18 leatherback, 778 loggerhead, 486 green and 3,884 Kemp's ridley). By comparison, the southeast Atlantic fishery had an estimated bycatch mortality of 1,033 turtles (8 leatherback, 673 loggerhead, 28 green and 324 Kemp's ridley) in 2010 (NMFS 2014c).

In 2014, NMFS issued a biological opinion for reinitiation of the section 7 consultation on the southeast shrimp trawl fishery (NMFS 2014c). Unlike most other fisheries, conventional observer programs are not effective for determining the numbers of sea turtle interactions and mortalities in this fishery. As a result, the ITS for this opinion is based on monitoring fishing effort and TED compliance rate as a surrogate for monitoring take. The baseline effort levels for this fishery, as established in the ITS, are 132,900 days fished in the Gulf of Mexico and 14,560 trips in the South Atlantic. The baseline TED compliance level is 88 percent.

The U.S. Atlantic pelagic longline fishery began in the early 1960s. This fishery is currently comprised of five distinct fishing sectors: Gulf of Mexico yellowfin tuna fishery; southern

Atlantic swordfish fishery; Mid-Atlantic and New England swordfish and tuna fishery; U.S. Atlantic Distant Water swordfish fishery; and the Caribbean tuna and swordfish fishery. The pelagic longline fishery mainly interacts with leatherback sea turtles and pelagic juvenile loggerhead sea turtles. The estimated average annual bycatch in this fishery (all geographic areas combined) between 1992-2002 was 912 loggerhead interactions (including 7 captured dead) and 846 leatherback interactions (including 11 captured dead) (NMFS 2004). These mortality estimates do not account for post-release mortality, which historically was likely substantial (NMFS 2014c). NMFS has taken numerous steps to reduce sea turtle bycatch and bycatch mortality in domestic longline fisheries. In 2001, NMFS implemented requirements for U.S. flagged vessels with pelagic longline gear on board to have line clippers and dipnets to remove gear on incidentally captured sea turtles (66 FR 17370). Specific handling and release guidelines designed to minimize injury to sea turtles were also implemented. In 2004, NMFS issued a biological opinion on reinitiation of a section 7 consultation on the Atlantic pelagic longline fishery (NMFS 2004). This opinion concluded that the pelagic longline fisheries were likely to jeopardize the continued existence of leatherback sea turtles. A Reasonable and Prudent Alternative was provided to avoid jeopardy that included take reduction measures related to fishing gear, bait, disentanglement gear, and training. NMFS published a final rule in 2004 to implement management measures to reduce sea turtle bycatch and bycatch mortality in the Atlantic pelagic longline fishery (69 FR 40734). Since 2004, bycatch estimates for both loggerheads and leatherbacks in pelagic longline gear have been well below the average prior to implementation of gear regulations under the Reasonable and Prudent Alternative (Garrison, Stokes, & Fairfield, 2012). The pelagic longline fishery resulted in an estimated 259 loggerhead and 268 leatherback sea turtle interactions in 2014 (NMFS, 2015).

In 2012, NMFS issued an updated biological opinion on the federal shark fisheries managed under the Consolidated Highly Migratory Species Fishery Management Plan (NMFS 2012a). Gears used to capture sharks in these fisheries include bottom longlines, gillnets (drift, strike, and sink nets), and commercial and recreational rod-and-reel and handlines. The ITS for this opinion exempted take of ESA-listed sea turtle species as follows:

- Green, North Atlantic DPS: up to 57 captures every three years of which 24 could be lethal.
- Hawksbill: up to 18 captures every three years of which nine could be lethal.
- Kemp’s ridley: up to 36 captures every three years of which 15 could be lethal.
- Leatherback: up to 18 captures every three years of which nine could be lethal.
- Loggerhead, Northwest Atlantic DPS: up to 126 captures every three years of which 78 could be lethal.

Sea turtles overlap seasonally with the Atlantic sea scallop fishery in the Mid-Atlantic region from Cape Cod, Massachusetts to southern Virginia when turtles migrate to this area to forage in early summer (Murray 2015). Loggerheads account for the large majority of interactions with this fishery. An estimated 200 interactions between loggerheads and scallop dredge fishing gear occurred on average annually from 2001 to early 2006 (Murray 2011). Subsequent fishing effort reductions and gear modifications implemented in this fishery reduced these interactions to less than 100 per year from late 2006 to 2008, and to an estimated 22 per year from 2009 to 2014 (Murray 2015).

Gillnets and bottom trawls are commonly used gears by many of the commercial fisheries operating in the northeastern U.S. Atlantic EEZ from North Carolina through Maine. These fisheries are also known to interact with large numbers of sea turtles, particularly loggerheads. waters from the North Carolina/South Carolina border to Chincoteague, Virginia. In 2013, NMFS issued a "batched" section 7 biological opinion on the following fisheries: Northeast multispecies; monkfish; spiny dogfish; Atlantic bluefish; Northeast skate complex; mackerel/squid/butterfish; and summer flounder /scup/black sea bass (NMFS, 2013). Gill net gear is used by five of the seven fisheries, and bottom trawl gear is used by six of the seven fisheries covered by this opinion. The "batched" fishery management plan opinion includes an ITS (amended March 10, 2016) that exempts the following take of Northwest Atlantic DPS loggerhead: up to 1,345 over any consecutive five-year period in gillnet gear, of which up to 835 may be lethal; up to 1,020 individuals over any consecutive five-year period in trawl gear, of which up to 335 may be lethal. Small numbers of leatherback, Kemp's ridley, and green sea turtles were also exempted in this ITS.

Other federal fisheries within the action area that result in sea turtle bycatch and have undergone recent section 7 consultation include the coastal migratory pelagics fishery in the Atlantic and Gulf of Mexico (NMFS 2015a), the South Atlantic commercial snapper-grouper fishery (NMFS 2006b), reef fish fisheries in the Gulf of Mexico (NMFS 2011b) and Caribbean (NMFS 2011a), the spiny lobster fisheries operating in the Gulf of Mexico, South Atlantic, and the Caribbean (NMFS 2011c) (NMFS 2009b), and the Gulf of Mexico stone crab fishery (NMFS 2009c). Various fishing gears (e.g., trawls, pots, pound nets and gillnets) used in state waters from Maine through Texas are known to incidentally take sea turtles. However, information on turtle bycatch in these coastal, nearshore fisheries is often sparse. Although the past and current effects of state managed fisheries on sea turtles is currently not determinable, NMFS believes that ongoing state fishing activities may be responsible for seasonally high levels of observed sea turtles strandings in state waters on both the Atlantic and Gulf of Mexico coasts.

The most effective way to monitor sea turtle bycatch is to place trained observers aboard fishing vessels. Although observer programs have increased in recent decades, many fisheries still lack the level of observer coverage necessary to produce reliable estimates of bycatch and associated mortalities needed to assess fishery impacts on ESA-listed species. In 2007, NMFS established a new regulation (72 FR 43176) to annually review sea turtle interactions across fisheries, identify those that require monitoring, and require fishermen to accommodate observers if requested. This annual process should help NMFS and the fishing industry learn more about sea turtle interactions with fishing operations, continually evaluate existing measures to reduce sea turtle takes, and determine whether additional measures to address prohibited sea turtle takes may be necessary to avoid exceeding established take limits.

Estimating sea turtle interactions and mortality rates associated with commercial fisheries globally remains challenging because a relatively small proportion of fisheries worldwide adequately monitor bycatch (Long and Schroeder 2004). Wallace et al. (2010) compiled a global database of reported marine turtle bycatch from 1990 to 2008 in gillnet, longline, and trawl fisheries. They concluded that bycatch is a moderate or high threat for more than three-fourths of all sea turtle regional management units, and represents the greatest overall threat to sea turtles globally (Wallace et al. 2010). Lewison et al. (2014) used the same 1990-2008 bycatch database as Wallace et al. 2010 to identify global hotspots of turtle bycatch intensity. High-intensity sea turtle bycatch was most prevalent in three regions: the eastern Pacific Ocean, southwest Atlantic Ocean, and Mediterranean Sea. In 1989, the U.S. passed legislation aimed at reducing the impact of global shrimp trawl fisheries bycatch on sea turtle populations. Section 609 of Public Law 101-162 prohibits the import of shrimp harvested with technology that may adversely affect certain species of sea turtles (16 U.S.C. 1537). The shrimp import prohibition does not apply if the Department of State certifies to Congress that the harvesting nation has a regulatory program and an incidental take rate comparable to that of the United States (that is, require and enforce the use of TEDs), or, alternatively, that the fishing environment in the harvesting nation does not pose a threat of the incidental taking of sea turtles (64 FR 36946).

8.8.2 Marine Mammal Fishery Interactions

Entanglement in fishing gear represents an important source of injury and mortality in marine mammals. Fisheries interactions are likely to have significant demographic effects on many populations of marine mammals (Read et al. 2006b). Bycatch mortality is estimated globally to exceed hundreds of thousands of marine mammals each year (Read et al. 2006b). Many marine mammals that die from entanglement in commercial fishing gear tend to sink rather than strand ashore, thus making it difficult to fully assess the magnitude of this threat. When not immediately fatal, entanglement or ingestion of fishing gear can impede the ability of marine mammals to feed and can cause injuries that eventually lead to infection and death (Cassoff et al. 2011; Moore and Van der Hoop 2012; Wells et al. 2008b). Other sublethal effects of entanglement include increased vulnerability to additional threats, such as predation and ship strikes, by restricting agility and swimming speed. There are also costs likely to be associated with nonlethal entanglements in terms of energy and stress (Moore and Van der Hoop 2012).

There is a strong spatial component to bycatch of marine mammals, with ‘hotspots’ influenced by marine mammal density and fishing intensity (Lewison et al. 2014). In the Atlantic Ocean, marine mammal bycatch occurs in a diversity of fisheries and is most important in various gillnet and trawl fisheries of New England and the Mid-Atlantic coast, and in the pelagic longline fisheries of the Atlantic, Gulf of Mexico, and Caribbean. Entanglement in fishing gear has been identified as one of the leading causes of North Atlantic right whale mortality and has been identified as a factor inhibiting recovery of the species (Knowlton et al. 2012b). The prevalence of scars on right whales associated with entanglements indicates the persistent and repetitive nature of this threat. Knowlton et al. (2012b) reported that from 1980-2009, 519 out 626 photo-identified right whales (82.9 percent) had been entangled at least once and 306 of the 519 (59.0 percent) had been entangled more than once. Of the 50 reported North Atlantic right whale deaths between 1986 and 2002, there were 18 (six confirmed and 12 presumed) cases of fatal gear entanglement (Kraus et al. 2005). Entanglement in fishing gear is also a significant threat to humpback whales in the Northwest Atlantic. Robbins (2009) found 64.9 percent of the Gulf of Maine humpback population to have entanglement scarring when first assessed in 2003, acquiring new scarring at an average annual rate of 12.1 percent.

8.8.3 Bycatch of ESA-listed Fish Species

Atlantic Salmon

Commercial bycatch is not thought to be a major source of mortality for Gulf of Maine DPS Atlantic salmon. Beland (1984) cited in (Fay et al. 2006b) reported that fewer than 100 salmon per year were caught incidental to other commercial fisheries in the coastal waters of Maine. A more recent study found that bycatch of Maine Atlantic salmon in herring fisheries is not a significant mortality source (ICES 2005). Commercial fisheries for white sucker, alewife, and American eel conducted in state waters also have the potential to incidentally catch Atlantic salmon.

Recreational angling occurs for many freshwater fish species throughout the range of the Gulf of Maine DPS Atlantic salmon. As a result, Atlantic salmon can be incidentally caught (and released) by anglers targeting other species such as striped bass or trout. Studies on the effects of catch and release on trout and salmon have concluded that exhaustive exertion may result in significant physiological disturbances including mortality (Brobbel et al. 1996; Graham et al. 1982; Wood et al. 1983). Conditions that contribute to Atlantic salmon post-release mortality include elevated water temperatures, exposure of the fish to air after capture, extremely soft water, low oxygen levels, low river flow and improper handling (Booth et al. 1995). The potential also exists for anglers to misidentify juvenile Atlantic salmon as brook trout, brown trout, or landlocked salmon. A maximum length for landlocked salmon and brown trout (25 inches) has been adopted in Maine in an attempt to avoid the accidental harvest of sea-run Atlantic salmon due to misidentification.

Atlantic and Shortnose Sturgeon

Atlantic and shortnose sturgeon are taken incidentally in fisheries targeting other species in rivers, estuaries, and marine waters throughout their range (ASSRT 2007; Collins et al. 1996). Sturgeon are benthic feeders and as a result they are generally captured near the seabed unless they are actively migrating (Moser and Ross 1995). Sturgeon are particularly vulnerable to being caught in commercial gill nets. Therefore, fisheries using this type of gear account for a high percentage of sturgeon bycatch and bycatch mortality. Sturgeon have also been documented in the following gears: otter trawls, pound nets, fyke/hoop nets, catfish traps, shrimp trawls, and recreational hook and line fisheries.

Estimated rates of Atlantic sturgeon caught as bycatch in federal fisheries are highly variable and somewhat imprecise due to small sample sizes of observed trips. An estimated 1,385 individual Atlantic sturgeon were killed annually from 1989 to 2000 as a result of bycatch in offshore gill net fisheries operating from Maine through North Carolina (Stein et al. 2004b). From 2001-2006 an estimated 649 Atlantic sturgeon were killed annually in offshore gill net and otter trawl fisheries. From 2006 to 2010 an estimated 391 Atlantic sturgeon were killed (out of 3,118 captured) annually in Northeast federal fisheries (Miller and Shepherd 2011).

Several federally regulated fisheries that may encounter Atlantic sturgeon have fishery management plans that have undergone section 7 consultation with NMFS. On December 16, 2013, NMFS issued a "batched" section 7 biological opinion on the following fisheries: Northeast multispecies; monkfish; spiny dogfish; Atlantic bluefish; Northeast skate complex; mackerel/squid/butterfish; and summer flounder /scup/black sea bass. The majority (73 percent) of all Atlantic sturgeon bycatch mortality in New England and Mid-Atlantic waters is attributed to the monkfish sink gill net fishery (ASMFC 2007). Observer data from 2001 to 2006 shows 224 recorded interactions between the monkfish fishery and Atlantic sturgeon, with 99 interactions resulting in death, a 44 percent mortality rate. For all seven fisheries combined, the following take of Atlantic sturgeon was authorized annually: 1,331 trawl interactions of which 42 may be lethal and 1,229 gill net interactions of which 155 may be lethal. The 2012 NMFS biological opinion on the Southeast shrimp trawl fishery exempted the take of Atlantic sturgeon as follows: 1,731 total interactions, including 243 captures of which 27 are expected to be lethal every three years. In 2012, NMFS provided an updated biological opinion on the Federal shark fisheries, including the smoothhound fishery on ESA-listed species. For the federal smoothhound fishery and shark fisheries combined, NMFS exempted the take of 321 Atlantic sturgeon over a three-year span, with 66 of those takes expected to be lethal.

Given the high prevalence of gill net and otter trawl use in nearshore coastal and inland fisheries, state managed fisheries may have a greater impact on Atlantic and shortnose sturgeon than federal fisheries using these same gear types. Commercially important state fisheries that interact with sturgeon include those targeting shrimp, Atlantic croaker, weakfish, striped bass, black drum, spot, shad, and spiny dogfish.

Gulf Sturgeon

Gulf sturgeon are susceptible to capture in commercial fisheries directed at other species that employ various trawling and entanglement gears. Gulf sturgeon are occasionally incidentally captured in state managed shrimp fisheries in bays and sounds along the northern Gulf of Mexico. Gulf sturgeon bycatch has also been documented in entanglement gear (trammel and gill nets) used to target gar in the Pearl River in southeast Louisiana, where (USFWS and NMFS 2009). While state regulations prohibit the taking or possession of Gulf sturgeon (including roe), there is no available data to determine bycatch capture or mortality rates (NMFS 2014c).

Relocation trawling, associated mostly with the removal of sea turtles to avoid interactions with channel dredging and beach nourishment projects, has successfully moved several Gulf sturgeon in recent years. These captures in near-shore waters illustrate the relative vulnerability of Gulf sturgeon to incidental bycatch in fisheries that use trawls (USFWS and NMFS 2009).

The Florida "net ban", approved by voter referendum in November 1994 and implemented in July 1995, made unlawful the use of entangling nets (i.e., gill and trammel nets) in Florida state waters. Other forms of nets (i.e., seines, cast nets, and trawls) were restricted, but not totally eliminated. Implementation of the net ban in Florida has likely benefited Gulf sturgeon as they are residents of near-shore waters during much of their life span.

Federal fisheries that NMFS authorizes in the Gulf of Mexico have likely had a minor impact on Gulf sturgeon. This is because Gulf sturgeon occur in the Gulf of Mexico only during winter months and during that time, most migrate alongshore and to barrier island habitats within shallower state waters (NMFS 2014c).

Oceanic Whitetip Shark

Oceanic whitetips are caught as bycatch in U.S. Atlantic pelagic longline (PLL) fisheries targeting tuna and swordfish. Relative to target species, oceanic whitetip sharks are caught infrequently and only incidentally on PLL vessels fishing for tuna and tuna-like species. From 1992-2000, elasmobranchs represented 15 percent of the total catch in numbers by the PLL fishery, with oceanic whitetip comprising 2.8 percent of the shark bycatch (Beerkircher et al. 2002). Observer data from the NMFS Pelagic Observer Program recorded 912 oceanic whitetip sharks caught on U.S. PLL gear between 1992 and 2015. Although oceanic whitetip sharks have been prohibited in fisheries with pelagic longline gear onboard since 2011 based on ICCAT Recommendation 10-07, they can still be caught as bycatch, caught with other gears, and are occasionally landed. Since the ICCAT retention prohibition was implemented, estimated commercial landings of oceanic whitetip declined from 1.1 mt in 2011 to only 0.03 mt in 2013 (NMFS 2014a). In 2013, NMFS reported a total of 33 oceanic whitetip interactions to ICCAT, with 88 percent released alive. Oceanic whitetips are also infrequently caught in buoy gear for swordfish; however, these interactions are relatively minimal, with 11 individuals caught from 2009-2015 (NMFS 2017a). In addition to information from the United States, international fisheries information and catch data for the Atlantic are available from ICCAT. Oceanic whitetip sharks are taken in the ICCAT convention area by longlines, purse seine nets, gillnets, trawls, and handlines; however, the large majority of the catch from 1990-2014 was caught by longline gear.

Giant Manta Ray

Manta rays are frequently caught as bycatch in a number of commercial and artisanal fisheries worldwide. In the Atlantic Ocean, bycatch of giant manta rays has been observed in purse-seine, trawl, and longline fisheries; however, as noted in Oliver et al. (2015), based on the available data, giant manta rays do not appear to be a significant component of the bycatch in these fisheries. In the U.S. bottom longline and gillnet fisheries operating in the western Atlantic, giant manta rays are also a rare occurrence in the elasmobranch catch. Based on data from the NMFS shark bottom longline observer program, between 2005 and 2014, only two giant manta rays were observed caught by bottom longline vessels fishing in the Gulf of Mexico and South Atlantic, with one discarded alive and one kept (data from 214 observed vessels, 833 trips, and 3,032 hauls) (Miller and Klimovich 2017a). Based on 1998–2015 data from the NMFS Southeast Gillnet Observer Program, which covers all anchored (sink and stab), strike, and drift gillnet fishing by vessels operating in waters from Florida to North Carolina and the Gulf of Mexico, the number of observed mantas in a given fishing year has ranged from zero to only 16, with the vast majority (around 89 percent) discarded alive (Miller and Klimovich 2017a).

Smalltooth Sawfish

The primary reason for the decline in smalltooth sawfish abundance has been bycatch in various commercial fishing gear, including gill nets, otter trawls, trammel nets, and seines (NMFS 2010c). The long, toothed rostrum of the smalltooth sawfish causes this species to be particularly vulnerable to entanglement in fishing nets. The majority of historical documented landings of smalltooth sawfish were from otter trawl fisheries. Total Gulf of Mexico landings dropped continually from around five metric tons in 1950 to less than 0.2 metric tons in 1978 (NMFS 2010c). Data gathered by Louisiana shrimp trawlers from 1945 to 1978 indicate a decline in smalltooth sawfish bycatch from a high of 34,900 pounds in 1949 to less than 1,500 pounds in most years after 1967 (Simpfendorfer 2002). Anecdotal information collected by NMFS port agents indicates that smalltooth sawfish are now taken very rarely in the shrimp trawl fishery. Smalltooth sawfish have been captured incidentally in federal shark fisheries using drift gillnets and bottom longlines, although interaction rates with these fisheries are relatively low. Smalltooth sawfish are also occasionally captured in recreational hook-and-line fisheries targeting shark, red drum, snook, and tarpon (NMFS 2010c).

The Florida net ban has led to a reduction in the number of smalltooth sawfish incidentally captured in nearshore commercial fisheries since 1995. The net ban made unlawful the use of entangling nets (i.e., gill and trammel nets) in Florida state waters. Other forms of nets (i.e., seines, cast nets, and trawls) were restricted but not completely eliminated.

Scalloped Hammerhead

Scalloped hammerhead sharks are both targeted and taken as bycatch in many global fisheries (e.g., bottom and pelagic longlines, coastal gillnet fisheries, artisanal fisheries). This species is highly desired for the shark fin trade because of its fin size and high fin ray count. In the U.S., scalloped hammerhead sharks are mainly caught as bycatch in longline and coastal gillnet fisheries and are known to suffer high post-release mortality rates. Many of the scalloped hammerhead sharks captured in U.S. fisheries are not from an ESA-listed DPS since the only non-foreign listed DPSs are the Central and Southwest Atlantic, Eastern Pacific, and Indo-West Pacific.

The NMFS Pelagic Observer Program reported 100 scalloped hammerhead bycaught in the U.S. Atlantic pelagic longline fishery in 2015, including 51 released dead (NMFS 2015d). Another 126 unidentified hammerhead sharks were also reported captured in this fishery, presumably some of which were scalloped hammerheads. In 2014, 138 scalloped hammerheads were caught during observed bottom longline trips in the sandbar shark research fishery in the Gulf of Mexico and Southern Atlantic (NMFS 2015d). In 2015, seven scalloped hammerheads were caught (five of which were released dead) during observed Southeast sink gillnet trips targeting Atlantic sharpnose, blacknose, and other shark species (NMFS 2015d). In the Pacific, shark bycatch occurs primarily in the Hawaii-based pelagic longline fishery. An observer program has been in place since 1995 with targeted coverage of 25 percent in the deep-set sector and 100 percent in the shallow-set sector. Observer data from 1995-2006 indicated a very low catch of scalloped hammerhead sharks in this fishery (56 individuals on 26,507 sets total, both fishery sectors combined) (Miller et al. 2013a). Scalloped hammerheads are also occasionally caught in U.S. recreational fisheries, although recreational catch estimates are often unreliable due to the rare event nature of capture and species identification issues.

8.9 Aquaculture

Marine aquaculture systems are diverse, ranging from highly controlled land-based systems to open water cages that release wastes directly to the environment. Species produced in the marine environment are also diverse, and include seaweeds, bivalve mollusks, echinoderms, crustaceans, and finfish (Langan 2004). Globally, aquaculture supplies more that 50 percent of all seafood produced for human consumption, and that percentage will likely continue to rise (NOAA Marine Aquaculture website https://www.fisheries.noaa.gov/topic/aquaculture). Marine aquaculture is expected to expand in the U. S. EEZ due to increased demand for domestically grown seafood, coupled with improved technological capacity to farm in the open ocean. The National Offshore Aquaculture Act of 2005 (S. 1195) promotes offshore aquaculture development within the EEZ and established a permitting process that encourages private investment in aquaculture operations, demonstrations, and research.

The growth of the aquaculture industry has drawn attention to the potential environmental impacts of offshore aquaculture, including impacts to protected species. Although aquaculture has the potential to relieve pressure on ocean fisheries, it can also threaten marine ecosystems through the introduction of exotic species and pathogens, effluent discharge, the use of wild fish to feed farmed fish, and habitat modification. The large amount of fixed gear (e.g., nets, cages, lines, buoys) used for open water aquaculture also represents an entanglement risk for many protected species. Entanglement in nets or lines around fish and mussel farms may cause injury, stress or death to marine mammals. Marine aquaculture operations may displace marine mammals from their foraging habitats or cause other disruptions to their behavior (Markowitz et al. 2004).

A variety of designs are used for open-ocean aquaculture. In the U.S., submersible cages are the model used for offshore finfish production (Naylor 2006). These cages are anchored to the ocean floor but can be moved within the water column; they are tethered to buoys that contain an equipment room and feeding mechanism; and they can be large enough to hold hundreds of thousands of fish in a single cage. One of the negative effects attributed to finfish culture is enrichment of the water column with dissolved nutrients, resulting from the decomposition of uneaten feed, and from metabolic wastes produced by the fish (Langan 2004). There is growing interest in marine aquaculture systems which combine fed aquaculture species (e.g. finfish), with inorganic extractive aquaculture species (e.g. seaweeds) and organic extractive species (e.g. suspension- and deposit-feeders) cultivated in proximity to mitigate these negative effects. Another type of offshore aquaculture system that is expected to grow is longline mussel aquaculture. At a typical commercial mussel farm, multiple backbone lines are arrayed in parallel rows submerged several meters (5– 20m) below the surface using a system of anchors and buoys (Price et al. 2016). The longlines may be 150– 300m in length. Submerged floats keep the vertical lines running up from the anchors and the horizontal longlines properly oriented in the water column and prevent the lines from becoming entangled with each other. In many parts of the world, a single farm may include several hundred longlines covering hundreds of acres. Currently in the United States, farms are typically being permitted at smaller scales (less than 100 acres), though it is anticipated that scaling up will follow once the domestic industry expands in the near future (Price et al. 2016).

It is generally thought that echolocating marine mammals (toothed whales, dolphins and porpoises) can effectively perceive mussel and fish farms and, in most cases, navigate through or around them (Llyod 2003; Markowitz et al. 2004). Species of baleen whales are not evolved to echolocate and rely on visual and audio queues, which may put them at higher risk of entanglement (Llyod 2003). Global reports of cetacean interactions with aquaculture gear include humpback whales is Australia, Canada and Iceland, Bryde's whales in New Zealand, right whales in South Korea, Argentina, and the North Atlantic Ocean (Price et al. 2016). There are three known incidents involving leatherback sea turtles being entangled in mussel ropes in Notre Dame Bay, Newfoundland from 2009 through 2013 (Price et al. 2016). One leatherback was documented entangled in shellfish aquaculture gear in the Greater Atlantic Region. This animal was entangled in the vertical line associated with the anchoring system. We found no published reports on sharks being entangled in aquaculture gear, and there is little published information about the interactions of sharks and marine farms (Price et al. 2016). Despite these reported incidence of entanglement, a literature review conducted by Price et al. (2016) does not indicate significant impacts to marine mammals, sea turtles or ESA-listed fish species from marine aquaculture structures and activities. The authors note that it is unclear if this is because aquaculture is relatively benign and poses little risk, or because the number and density of farms is so low that the detection level for harmful interactions is also very small (Price et al. 2016).

8.10 Vessel Approaches – Commercial and Private Whale Watching

Several studies have investigated the behavioral responses of cetaceans to vessel approaches. Behavioral responses to close approaches reported in the literature suggest that individual whales experience stress responses to vessels. While these stimuli are likely stressful, the fitness consequences of this stress on individual whales remains unknown (Baker and Herman 1987; Baker et al. 1983b). Beale and Monaghan (2004a) concluded that the significance of disturbance was a function of the distance of humans to the animals, the number of humans making the close approach, and the frequency of the approaches. These results would suggest that the cumulative effects of the various human activities in the action area would be greater than the effects of the individual activity.

Baker *et al.* (1983b) described two responses of whales to vessels, including: (1) "horizontal avoidance" of vessels 2,000 to 4,000 m away characterized by faster swimming and fewer long dives; and (2) "vertical avoidance" of vessels from 0 to 2,000 m away during which whales swam more slowly, but spent more time submerged. Watkins *et al.* (1981) found that both fin and humpback whales appeared to react to vessel approach by increasing swim speed, exhibiting a startled reaction, and moving away from the vessel with strong fluke motions. Results were different depending on the social status of the whales being observed (single males when compared with cows and calves), but humpback whales generally tried to avoid vessels when the vessels were 0.5 to 1.0 kilometer from the whale. Smaller pods of whales and pods with calves seemed more responsive to approaching vessels (Bauer 1986a; Bauer and Herman 1986b). Bauer (1986a) and Bauer and Herman (1986b) noted changes in humpback whale respiration, diving, swimming speed, social exchanges, and other behavior correlated with the number, speed, direction, and proximity of vessels.

Studies of other baleen whales, specifically bowhead and gray whales, document similar patterns of behavioral disturbance in response to a variety of actual and simulated vessel activity and noise (Malme et al. 1983; Richardson et al. 1985b). For example, studies of bowhead whales revealed that these whales oriented themselves in relation to a vessel when the engine was on, and exhibited significant avoidance responses when the vessel's engine was turned on even at a distance of about 900 m (3,000 ft). Jahoda *et al.* (2003b) studied the response of 25 fin whales in feeding areas in the Ligurian Sea to close approaches by inflatable vessels and to biopsy samples. They concluded that close vessel approaches caused these whales to stop feeding and swim away from the approaching vessel. The whales also tended to reduce the time they spent at surface and increase their blow rates, suggesting an increase in metabolic rates that might indicate a stress response to the approach. In their study, whales that had been disturbed while feeding remained disturbed for hours after the exposure ended. They recommended keeping vessels more than 200 m from whales and having approaching vessels move at low speeds to reduce visible reactions in these whales.

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, whale watching has the potential to harass whales by altering feeding, breeding, and social behavior or even injure them if the vessel gets too close or strikes a whale. Another concern is that preferred habitats may be abandoned if disturbance levels are too high. In the Notice of Availability of Revised Whale Watch Guidelines for Vessel Operations in the Northeastern United States (64 FR 29270; June 1, 1999), NMFS noted that whale watch vessel operators seek out areas where whales concentrate, which has led to numbers of vessels congregating around groups of whales, increasing the potential for harassment, injury, or even the death of these animals. Several studies have specifically examined the effects of whale watching on marine mammals, and investigators have observed a variety of short-term responses from animals, ranging from no apparent response to changes in vocalizations, duration of time spent at the surface, swimming speed, swimming angle or direction, respiration rate, dive time, feeding behavior, and social behavior (NMFS 2006a). Responses appear to be dependent on factors such as vessel proximity, speed, and direction, as well as the number of vessels in the vicinity. Foote et al. (2004b) found that southern resident killer whale call duration increased by 10-15 percent in the presence of whale watching boats, suggesting the whales compensate for a noisier environment. Disturbance by whale watch vessels has also been noted to cause newborn calves to separate briefly from their mothers' sides, which leads to greater energy expenditures by the calves (NMFS 2006a). Although numerous short-term behavioral responses to whale watching vessels are documented, little information is available on whether long-term negative effects result from this activity (NMFS 2006a).

8.11 Vessel Strike

Marine habitats occupied by ESA-listed species often feature both heavy commercial and recreational vessel traffic. Vessel strikes represent a recognized threat to several taxa of large air breathing marine vertebrates, including whales and sea turtles. The International Whaling Commission noted that human-induced mortality caused by vessel strikes can be an impediment to cetacean population growth (IWC 2017). Most whales killed by vessel strike likely end up sinking rather than washing up on shore, and it is estimated that 17 percent of vessel strikes are actually detected (Kraus et al. 2005). Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of mortalities associated with vessel strikes.

Various types and sizes of vessels have been involved in ship strikes with large whales, including container/cargo ships/freighters, tankers, steamships, military vessels, cruise ships, ferries, recreational vessels, research vessels, fishing vessels, whale-watching vessels, and other vessels (Jensen and Silber 2004b). The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately ten knots, with faster vessels, especially of large vessels (80 m or greater), being more likely to cause serious injury or death (Conn and Silber 2013c; Jensen and Silber 2004a; Laist et al. 2001; Vanderlaan and Taggart 2007). Injury is generally caused by the rotating propeller blades, but blunt injury from direct impact with the hull also occurs. Injuries to whales killed by vessel strikes include huge slashes, cuts, broken vertebrae, decapitation, and animals cut in half (Carillo and Ritter 2008). From 2007 through May 2017, the Navy reported four whale strikes in the action area (an average of 0.39 per year), with the last strike occurring in 2012. For the 10-year period (1997-2006) prior to the implementation of the original Marine Species Awareness Training in 2007, the Navy reported 15 whale strikes during Navy activities (an average of 1.5 per year) in the action area, which is more than three times the amount reported for 2007-2017. It is likely that the implementation of the Marine Species Awareness Training starting in 2007, and the additional U.S. Navy Afloat Environmental Compliance Training Series modules starting in 2014, has contributed to this reduction in strikes.

Van Der Hoop et al. (2015) reviewed data on 1,198 Atlantic large whales (mainly baleen species, but also sperm whales) from 1990-2012 and found that 135 deaths (11 percent) of the 458 diagnosed cases were caused by vessel strike. Following implementation of a ship strike rule, which slowed speeds in management areas, from 2007-2012, 33 percent of North Atlantic right whale population deaths were caused by vessel strike. Van Der Hoop et al. (2015) concluded that closure areas, in addition to other factors, have been effective at reducing, but not eliminating, North Atlantic right whale deaths by vessel strike. Even after the ship speed rule was implemented, seasonal closures were ineffective, at least in part, as ship strike remained the second highest diagnosed cause of death for all large whales in the Atlantic along the U.S. east coast for the time period in that study (Van Der Hoop et al. 2015). Forty-three fatally ship-struck sperm whales have been reported in the Atlantic Ocean between 1987 and 2010 (IWC Ship

Strike Database, http://iwc.int/index.php?cID=872&cType=document*)*. Of 123 humpback whales that stranded along the Atlantic coast of the U.S. between 1975 and 1996, 10 (8.1 percent) showed evidence of collisions with ships (Laist et al. 2001). Between 1999 and 2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic coast of the U.S. and the Maritime Provinces of Canada (Cole et al. 2005; Nelson et al. 2007). Of three sei whales that stranded along the U.S. Atlantic coast during 1975-1996, two showed evidence of collisions (Laist et al. 2001). Between 1999 and 2005, there were three reports of sei whales being struck by vessels along the U.S. Atlantic coast and Canada's Maritime Provinces (Cole et al. 2005; Nelson et al. 2007). Two of these ship strikes were reported as having resulted in death. Photo identification showing sperm whales with scars indicate that non-fatal collisions with ships are also occurring regularly (ACCOBAMS 2005).

Vessel strikes represent one of the greatest threats to the continued existence of North Atlantic right whales. Between 1999 and 2006, vessels were confirmed to have struck 22 North Atlantic right whales, killing 13 of these whales (Jensen and Silber 2004a; Knowlton and Kraus 2001; NMFS 2005b). From 2006 to 2010, ten instances of mortality stemming from vessel collision were documented (Waring et al. 2013). However, with the implementation of the 2008 mandatory right whale vessel strike reduction rule and increased communication through the usage of the Automatic Identification System, reported instances of North Atlantic right whale mortalities from vessel strikes have significantly decreased (Conn and Silber 2013b). The rule resulted in implementation of speed restrictions of ten knots or less for vessels 65 ft in length or greater for several areas along the western Atlantic during specified times of the year (50 CFR 224.105). From 2008 to 2014 only two reported mortalities have been recorded for North Atlantic right whales due to vessel strike, resulting in a nearly 80 to 90 percent reduction of occurrence from previous time spans (Henry et al. 2015; Henry et al. 2016; Waring et al. 2015). However, the results of necropsies for some of the North Atlantic right whales found dead in the 2017 unusual mortality event indicate evidence of blunt force trauma, possibly from a vessel strike (Dauoust 2017).

A summary of known mortalities and serious injuries related to vessel strikes of ESA-listed cetaceans within U.S. waters in recent years is shown in Table 62. These data represent only known mortalities and serious injuries; more, undocumented mortalities and serious injuries have likely occurred as commercial vessels are not required to report vessel strikes. In addition, these data do not include the recent deaths of North Atlantic right whales associated with the ongoing Unusual Mortality Event.

Table 62. Number of reported cetacean vessel strikes in U.S. waters from 2011 to 2015 (2008-2012 for sperm whales) (Hayes et al. 2017; Henry et al. 2017).

Species	Number of Vessel Strikes*	Annual Average
Blue whales	0	0
Fin whales	8	1.6
North Atlantic right whales	5	1
Sei whales	4	0.8
Sperm whales	1	0.2

Note: None of these strikes were from U.S. Navy vessels.

Impact from a boat hull or outboard motor, or cuts from a propeller can kill or severely injure turtles. Many recovered turtles display injuries that appear to result from interactions with vessels and their associated propulsion systems (Work et al. 2010c). Turtles may use auditory cues to react to approaching vessels rather than visual cues, making them more susceptible to strike as vessel speed increases (Hazel et al. 2007). Results from a study by Hazel et al. (2007) suggest that green turtles cannot consistently avoid being struck by vessels moving at relatively moderate speeds (i.e., greater than four kilometers per hour). Vessel strikes have been identified as one of the important mortality factors in several near shore turtle habitats worldwide (Denkinger et al. 2013a).

High levels of vessel traffic in nearshore areas along the U.S. Atlantic and Gulf of Mexico coasts result in frequent injury and mortality of sea turtles. From 1997 to 2005, nearly 15 percent of all stranded loggerheads in this region were documented as having sustained some type of propeller or collision injury, although it is not known what proportion of these injuries were sustained ante-mortem versus post mortem. In one study from Virginia, Barco et al. (2016a) found that all 15 dead loggerhead turtles encountered with signs of acute vessel interaction were apparently normal and healthy prior to human-induced mortality. The incidence of propeller wounds of stranded turtles from the U.S. Atlantic and Gulf of Mexico doubled from about ten percent in the late 1980s to about 20 percent in 2004. Singel et al. (2007) reported a tripling of boat strike injuries in Florida from the 1980's to 2005. Over this time period, in Florida alone over 4,000 (~500 live; ~3500 dead) sea turtle strandings were documented with propeller wounds, which represents 30 percent of all sea turtle strandings for the state (Singel et al. 2007). These studies suggest that the threat of vessel strikes to sea turtles may be increasing over time as vessel traffic continues to increase in the southeastern U.S. and throughout the world.

Sturgeon are susceptible to vessel strikes due to their large size and frequent use of coastal waterways with heavy commercial vessel traffic. The factors relevant to determining the risk to sturgeon from vessel strikes are currently unknown, but are likely related to size and speed of the vessels, navigational clearance (i.e., depth of water and draft of the vessel) in the area where the vessel is operating, and the behavior of sturgeon in the area (e.g., foraging, migrating, etc.). The ASSRT determined Atlantic sturgeon in the Delaware River are at a moderately high risk of extinction because of ship strikes, and sturgeon in the James River are at a moderate risk from ship strikes (ASSRT 2007). Balazik et al. (2012c) estimated up to 80 sturgeon were killed between 2007 and 2010 in these two river systems. Brown and Murphy (2010) examined 28 dead Atlantic sturgeon from the Delaware River from 2005 through 2008 and found that fifty percent of the mortalities resulted from apparent vessel strikes, and 71 percent of these (10 out of 14) had injuries consistent with being struck by a large vessel. Eight of the fourteen vessel-struck sturgeon were adult-sized fish which, given the time of year the fish were observed, were likely migrating through the river to or from the spawning grounds. Ship strikes may also be threatening Atlantic sturgeon populations in the Hudson River where large ships move from the river mouth to ports upstream through narrow shipping channels. The channels are dredged to the approximate depth of the ships, usually leaving less than six feet of clearance between the bottom of ships and the river bottom. Any aquatic life along the bottom is at risk of being sucked up through the large propellers of these ships.

Large Atlantic sturgeon are most often killed by ship strikes because their size means they are unable to pass through the ship's propellers without making contact. Shortnose sturgeon may not be as susceptible due to their smaller size in comparison to Atlantic sturgeon. There has been only one confirmed incidence of a ship strike on a shortnose sturgeon in the Kennebec River, and two suspected ship strike mortalities in the Delaware River (SSSRT 2010). Smalltooth sawfish may also been susceptible to ship strikes, but there is no available information on this threat to these species.

8.12 Invasive Species

The introduction of non-native species is considered one of primary threats to ESA-listed species (Anttila et al. 1998; Pimentel et al. 2004; Wilcove and Chen 1998). Clavero and Garcia-Bertro (2005) found that invasive species were a contributing cause to over half of the extinct species in the IUCN database and invasive species were the only cited cause in 20 percent of those cases. Invasive species consistently rank as one of the top threats to the world's oceans (Pughiuc 2010; Raaymakers 2003; Raaymakers and Hilliard 2002; Terdalkar et al. 2005; Wambiji et al. 2007).

When non-native plants and animals are introduced into habitats where they do not naturally occur, they can have significant impacts on ecosystems and native fauna and flora (including ESA-listed species). Non-native species can be introduced through infested stock for aquaculture and fishery enhancement, ballast water discharge, and from the pet and recreational fishing industries. In general, species located higher within a food web (including most ESA-listed species under NMFS' jurisdiction) are more likely to become extinct as a result of an invasion; conversely, species that are more centrally or bottom-oriented within a food web are more likely to establish (Byrnes et al. 2007; Harvey and May 1997). Propagule pressure is generally the reason for this trend, as individuals lower in the food web tend to have higher fecundity and lower survival rates (r-selection). This unbalancing of food webs makes subsequent introductions more likely as resource utilization shifts, increasing resource availability, and exploitation success by non-native species (Barko and Smart 1981; Byrnes et al. 2007). Such shifts in the base of food webs fundamentally alters predator-prey dynamics up and across food chains (Moncheva and Kamburska 2002).

For example, invertebrates can have major impacts on the ecosystems they invade. Benthic invertebrates, such as mussels, polychaetes, and hydroids can become dominant filter feeders, greatly reducing the amount of organic energy that is available to native taxa in the water column (NMFS 2012b). This transfer of energy from the water column into the benthos fundamentally alters the ecology of the host habitat, resulting in less prey available for other filter feeders. Adverse effects of this include reduced body condition, growth, survival, and/or reproduction of native pelagic organisms at the same or similar trophic level as the invader if the native competitor cannot adapt to another food source. These changes would be manifested to a greater or lesser degree up the food chain to higher trophic level organisms in the habitat, including ESA-listed sturgeon and sea turtles (NMFS 2012b). Invasives species may also prey upon ESA-listed species. For example, the crown-of-thorns sea star *Acanthaster planci* can significantly disrupt localized coral reef ecosystems by feeding on live coral (e.g., Colgan 1987; Timmers et al. 2012), including the ESA-listed coral considered in this opinion.

Red tide dinoflagellates have been introduced via ballast water discharges and have the potential to undergo extreme seasonal population fluctuations, potentially resulting in significant adverse effects to ESA-listed species. During bloom conditions, high levels of neurotoxins are released into local and regional surface water and air that can cause illness and death in fishes, sea turtles, marine mammals, and invertebrates (as well as their larvae) (Hallegraeff and Bolch 1992; Hallegraeff 1998; Hamer et al. 2001; Hamer et al. 2000; Lilly et al. 2002; McMinn et al. 1997). The brown alga, *Aureococcus anophagefferens*, causes brown tide when it blooms, causing diebacks of eelgrass habitat due to blooms decreasing light availability and failure of scallops and mussels to recruit (Doblin et al. 2004).

Invasive species can adversely affect listed fish species through several mechanisms, including: predation, competition, trophic structure alteration, introgression, and transfer of pathogens (Sanderson et al. 2009). Both positive and negative impacts to fish species have been reported in the literature from the introduction of nonindigenous species (Schlaepfer et al. 2011). For example, channel catfish, small and largemouth bass, and walleye prey on juvenile salmon (Sanderson et al. 2009). Juvenile shad prey heavily on zooplankton, which are also the primary prey for juvenile salmonids (Haskell et al. 2006). Alternatively, some introduced species may serve as a food source for native species in the introduced environment. Vinson and Baker (2008) found that the nonindigenous mudsnail (*Potamopyrgus antipodarum*) was an abundant prey item for native salmonids. However, when native salmonids feed exclusively on mudsnails, this study found they lose 0.5 percent of their body weight per day. This study suggests that, in some cases, even if nonindigenous invertebrate species can provide a new food source, the resulting effect can still be detrimental to native fish species if the nonindigenous prey is not as nutritionally valuable as the native prey items that it is replacing.

8.13 Diseases

Fibropapillomatosis is a neoplastic disease that can negatively impact ESA-listed sea turtle populations. Fibropapillomatosis has long been present in sea turtle populations with the earliest recorded mention from the late 1800s in the Florida Keys (Hargrove et al. 2016). Prevalence rates as high as 45 to 50 percent have been reported within some local green turtle populations (Hargrove et al. 2016; Jones et al. 2015). Fibropapillomatosis is characterized by both internal and external tumorous growths, which can range in size from very small to extremely large. Large tumors can interfere with feeding and essential behaviors, and tumors on the eyes can cause permanent blindness (Foley et al. 2005). Renan de Deus Santos et al. (2017) assessed stress responses (corticosterone, glucose, lactate, and hematocrit) to capture and handling in green sea turtles with different fibropapillomatosis severity levels. Their findings suggest that moderate fibropapillomatosis severity may affect a turtle's ability to adequately feed themselves (as evidenced by poor body condition), and advanced-stage fibropapillomatosis severity may result in an impaired corticosterone response. Despite some conflicting conclusions, the overwhelming consensus among turtle researchers is that, at present, fibropapillomatosis does not significantly impact the overall survival of sea turtle populations (Hargrove et al. 2016). However, fibropapillomatosis cannot be discounted as a potential threat to sea turtle populations (particularly green turtles) as the distribution, prevalence rate, severity, and environmental co-factors associated with the disease have the capacity to change over time (Jones et al. 2015).

Fish diseases and parasitic organisms occur naturally in the water. Many fish species are highly susceptible to parasites and disease, particularly during early life stages. Native fish have co-evolved with such organisms and individuals can often carry diseases and parasites at less than lethal levels. While disease organisms commonly occur among wild fish populations, under favorable environmental conditions these organisms are not expected to cause population-threatening epizootics. However, outbreaks may occur when stress from disease and parasites is compounded by other stressors such as diminished water quality, flows, and crowding (Guillen 2003; Spence and Hughes 1996). At higher than normal water temperatures fish species may become stressed and lose their resistance to diseases (Spence and Hughes 1996). Consequently, diseased fish become more susceptible to predation and are less able to perform essential functions, such as feeding, swimming, and defending territories (McCullough 1999). The introduction of non-indigenous fish pathogens to wild fish populations through aquaculture operations also represents a threat to some fish populations. The aquarium industry is another possible source for transfer of non-indigenous pathogens or non-indigenous species from one geographic area to another, primarily through release of aquaria fish into public waters.

Cetaceans have evolved with a group of parasites belonging to the genus *Crassicauda* (order Spirurida) (Lambertsen 1992). Infections with these nematodes are endemic in both the toothed and baleen whales. Such infections are a major cause of disease of the urinary, respiratory and digestive systems. Of several known crassicaudid infections, those caused by *Crassicauda boopis* are especially pathogenic. This giant worm infects blue whales, humpback whales, and fin whales (Lambertsen 1992). Jauniaux et al. (2000) reported evidence for morbillivirus infection in the two fin whales stranded on the Belgian and French coastlines.

Salmonids are susceptible to numerous bacterial, viral, and fungal diseases. The more common bacterial diseases in New England waters include furunculosis, bacterial kidney disease, enteric redmouth disease, coldwater disease, and vibriosis (Egusa and Kothekar 1992; Olafesen and Roberts 1993; USFWS and Gaston 1988). Furunculosis, which is particularly widespread, can be a significant source of mortality in wild Atlantic salmon populations if river water temperatures become unusually high for extended periods (USFWS and Gaston 1988). Whirling disease is a parasitic infection caused by the microscopic parasite *Myxobolus cerebrali*. Infected fish continually swim in circular motions and eventually expire from exhaustion. The disease occurs both in the wild salmonids and in hatcheries. Saprolegnia is a fungal disease of Atlantic salmon and is primarily found in adult males. It invades the epidermis and is associated with the presence of high levels of androsteroids (Olafesen and Roberts 1993; USFWS and Gaston 1988).

In 1996, the first occurrence of the infectious salmon anemia virus in North America was found in an aquaculture facility in New Brunswick, Canada (Fay et al. 2006b). The first outbreak of infectious salmon anemia in the United States was reported in 2001 in an aquaculture facility in Cobscook Bay, Maine. Approximately 925,000 fish were removed from aquaculture pens throughout the Bay that year, and eventually all cultured salmon in the Bay had to be removed (Fay et al. 2006b). While captive fish have the highest risk for transmission and outbreaks of diseases such as infectious salmon anemia, wild fish that must pass near aquaculture facilities are at risk of encountering both parasites and pathogens from hatchery operations. Although substantial progress has been made in recent years to reduce the risks to wild fish posed by aquaculture, this remains a potential threat.

8.14 Scientific Research and Permits

Information obtained from scientific research is essential for understanding the status of ESA-listed species, obtaining specified critical biological information, and achieving species recovery goals. Research on ESA-listed species is granted an exemption to the ESA take prohibitions of section 9 through the issuance of section 10(a)(1)(A) permits. Research activities authorized through scientific research permits can produce various stressors on wild and captive animals resulting from capture, handling, and research procedures. The ESA requires that research conducted under a section 10(a)(1)(A) research permit cannot operate to the disadvantage of the species. Scientific research permits issued by NMFS are conditioned with mitigation measures to ensure that the impacts of research activities on target and non-target ESA-listed species are as minimal as possible.

Over time, NMFS has issued dozens of permits on an annual basis for various forms of “take” of marine mammals, sea turtles, and ESA-listed fish species in the action area from a variety of research activities. Authorized research on ESA-listed whales and dolphins includes close vessel and aerial approaches, photographic identification, photogrammetry, biopsy sampling, tagging, ultrasound, exposure to acoustic activities, breath sampling, behavioral observations, passive acoustic recording, and underwater observation. Only non-lethal "takes" of marine mammals are authorized for research activities.

ESA-listed sea turtle research includes approach, capture, handling, restraint, tagging, biopsy, blood or tissue sampling, lavage, ultrasound, imaging, antibiotic (tetracycline) injections, laparoscopy, captive experiments, and mortality. Most authorized take is sub-lethal as mortality is rarely authorized by NMFS in sea turtle research permits. On average, from 2007 to 2017 approximately 988 sea turtle (all species) takes were reported within the research program throughout the U.S. in any given year. Five permits, all for research in the Atlantic Ocean basin, authorized lethal take between 2007 and 2017. In 2017, NMFS concluded section 7 consultation on a Program for the Issuance of Permits for Research and Enhancement Activities on Threatened and Endangered Sea Turtles Pursuant to Section 10(a) of the ESA. This programmatic consultation allows for the authorization of up to the following number of sea turtle mortalities within the Atlantic Ocean basin every ten years: 17 green (N. Atlantic and S. Atlantic DPSs combined); nine hawksbill; 12 Kemp's ridley; 16 leatherback; 20 loggerhead (NW Atlantic DPS); and nine olive ridley. This programmatic also includes an ITS that allows for two smalltooth sawfish lethal takes every ten years and one lethal take of each of the following ESA-listed fish species every ten years: Atlantic salmon, Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, Nassau grouper, and scalloped hammerhead.

Since 2006, conservative mitigation measures implemented by NMFS through permit conditions (e.g., reduced soak times at warmer temperatures or lower dissolved oxygen concentrations, minimal holding or handling time) and additional precautions taken by sturgeon researchers have significantly reduced the lethal and sublethal effects of capture in gill, trammel and trawl nets on Atlantic and shortnose sturgeon. From 2006 through 2016, researchers reported only two shortnose sturgeon killed by capture gear out of 7,019 captured, for a capture mortality rate of 0.03 percent. Since they were listed in 2012, the mortality rate associated with Atlantic sturgeon capture in scientific research is 0.22 percent (14 killed out of 6,466 captured). In 2017, the Permits Division implemented a program for the issuance of permits for research and enhancement activities on Atlantic sturgeon and shortnose sturgeon. A section 7 programmatic consultation biological opinion determined that this action would not likely jeopardize the continued existence of ESA-listed species and would not likely result in the destruction or adverse modification of critical habitat. In addition to the required mitigation measures designed to reduce lethal take and sub-lethal effects on sturgeon, the program establishes annual limits on sturgeon mortality resulting from research activities by subpopulation (i.e., spawning stock) and life stage. Relative mortality limits are calculated as a proportion of the estimated population size and are based on the relative health of the population. A health index is calculated by NMFS based on the best available information on the population including abundance, population trends, known threats, and information on spawning activity. For adults/sub adults and juveniles, relative annual maximum mortality limits are set at 0.4, 0.6, and 0.8 percent of the estimated population size for sturgeon populations with a health index rating of "low," "medium," and "high," respectively. For populations where there is insufficient information to calculate a health index or there is no estimate of population size, the default maximum mortality limit is conservatively established at one fish per year. Maximum annual mortality limits can be exceeded in any given year by up to two times, as long as the five-year moving average is within the established maximum annual mortality limit for that population and life stage.

There are currently three permits issued for research on smalltooth sawfish. The NMFS Permits Division and Interagency Cooperation Division are currently working on a programmatic consultation for the issuance of permits for research and enhancement activities on the U.S. DPS of smalltooth sawfish. Since their listing in 2003, only one smalltooth sawfish mortality has been reported as a result of research authorized under a section 10(a)(1)(A) permit. As with turtles and sturgeon, mitigation measures implemented by NMFS through permit conditions and additional precautions taken by researchers have significantly reduced the lethal and sublethal effects of research activities on smalltooth sawfish.

The U.S. Fish and Wildife Service issues section 10(a)(1)(A) permits for Atlantic salmon. For Gulf sturgeon, a special rule promulgated at the time of listing (56 FR 49658) gives the states permitting authority to allow taking of this species, in accordance with applicable state laws, for educational purposes, scientific purposes, and enhancement of propagation.

8.15 The Impact of the Environmental Baseline on ESA-Listed Resources

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on the ESA-listed resources considered in this consultation. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strike, whaling, entanglement in fishing gear), whereas others result in more indirect (e.g., a fishery that impacts prey availability) or non-lethal impacts (e.g., whale watching). Assessing the aggregate impacts of these stressors on species is difficult and, to our knowledge, no such analysis exists. This becomes even more difficult considering that many of the species in this opinion are wide ranging and subject to stressors in locations throughout the action area and outside the action area.

We consider the best indicator of the aggregate impact of the *Environmental Baseline* on ESA-listed resources to be the status and trends of those species. As noted in Section 7.2, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the *Environmental Baseline* is impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the *Environmental Baseline*. Therefore, while the *Environmental Baseline* may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in the *Environmental Baseline* is preventing their recovery. However, it is also possible that their populations are at such low levels (e.g., due to historic commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species is discussed in the 7.2 of this opinion.

9 EFFECTS OF THE ACTION

Section 7 regulations define "effects of the action" as the direct and indirect effects of an action on the species or designated critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 C.F.R. §402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are reasonably certain to occur.

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

The destruction and adverse modification analysis considers whether the action produces "a direct or indirect alteration that appreciably diminished the value of designated critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features." 50 C.F.R. 402.02.

Previously in Section 6, we identified the potential stressors created by the Navy's testing and training activities. This section (Section 9) begins with a summary table of our effects determination by stressor category for each taxa and for each species (Table 63). This serves as a cross reference for the sections to follow that provide the analyses supporting these effects determinations.

Recall that in Section 7, we provided a complete list of ESA-listed species and designated critical habitat that may be affected by the proposed action. Further, in Section 7.1, we explained that some ESA-listed species and designated critical habitat were not likely to be adversely affected by any of the stressors associated with the proposed action. This is because any effects were extremely unlikely to occur such that they were discountable, or the size or severity of the impact was so low as to be insignificant, including those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. The ESA-listed species addressed in Section 7.1 are included in the summary table below because this table reflects all species considered during consultation. However, ESA-listed species determined in Section 7.1 to not likely be adversely affected by any of the stressors associated with the proposed action are not discussed again in this opinion.

In this section (Section 9), we discuss species and designated critical habitat that are *likely to be adversely affected* by at least one stressor associated with the proposed action (See Section 7.2 for the list of these species and designated critical habitat considered in this section). In Section 9.1, we discuss the stressors associated with the proposed action that we determined are *not likely to adversely affect* all species from a particular taxa (e.g., marine mammals, sea turtles) and designated critical habitat (i.e., in the taxa row, labeled as NLAA in Table 63). We do not discuss these stressors again in this opinion. Finally, in Section 9.2, we summarize our analysis for the stressors and ESA-listed species combinations that are likely to result in adverse effects to individual ESA-listed resources (in the taxa row of Table 63, labeled as LAA).

Table 63. National Marine Fisheries Service ESA effects determinations by stressor for each species. The table also lists the overall effect determination by taxa for each stressor.

Note: If the determination for a particular taxa is not likely to adversely affect (NLAA), that analysis for that taxa and stressor is in section 9.1 of this opinion. If the determination for a particular taxa is likely to adversely affect (LAA), the analysis for that taxa and stressor is in section 9.2 of this opinion. "-" reflects a No Effect determination by the Navy for a particular stressor.

ESA-Listed Species	Overall Determination	Acoustic Stressors						Explosive Stressors	Energy Stressors		Physical Disturbance and Strike Stressors				Entanglement Stressors			Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosions	In-Water Electromagnetic Devices	High Energy Lasers	Vessels	In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/Parachutes	Biodegradable Polymer	Military Expended Materials – Munitions	Military Expended Materials – Other than Munitions	
Marine Mammals	**LAA**	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Blue whale	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Fin whale	**LAA**	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Bryde's whale – Gulf of Mexico DPS	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
North Atlantic right whale	**LAA**	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sei whale	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sperm whale	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Bowhead whale	NLAA	-	-	-	NLAA	-	-	-	-	-	NLAA	-	-	-	-	-	-	-	-	-
Ringed seal	NLAA	-	-	-	NLAA	-	-	-	-	-	NLAA	-	-	-	-	-	-	-	-	-
Sea Turtles	**LAA**	**LAA**	**LAA**	**LAA**	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Green – North Atlantic DPS	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Hawksbill	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Kemp's ridley	**LAA**	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Leatherback	**LAA**	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Loggerhead – Northwest Atlantic DPS	**LAA**	**LAA**	**LAA**	**LAA**	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Fishes	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Atlantic salmon - Gulf of Maine DPS	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	-	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Atlantic Sturgeon – Gulf of Maine DPS	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Atlantic Sturgeon – New York Bight DPS	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Atlantic Sturgeon – Chesapeake Bay DPS	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-Listed Species	Overall Determination	Acoustic Stressors						Explosive Stressors	Energy Stressors		Physical Disturbance and Strike Stressors				Entanglement Stressors			Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosions	In-Water Electromagnetic Devices	High Energy Lasers	Vessels	In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/Parachutes	Biodegradable Polymer	Military Expended Materials – Munitions	Military Expended Materials – Other than Munitions	
Atlantic Sturgeon – Carolina DPS	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Atlantic Sturgeon - South Atlantic DPS	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	LAA	NLAA	NLAA
Gulf sturgeon	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Shortnose sturgeon	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Giant Manta Ray	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Nassau Grouper	NLAA	NLAA	-	-	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Oceanic whitetip shark	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Scalloped hammerhead sharks	**LAA**	NLAA	-	-	NLAA	NLAA	NLAA	**LAA**	-	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Smalltooth sawfish	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Invertebrates	**LAA**	NLAA	-	-	NLAA	-	-	NLAA	NLAA	-	NLAA	-	**LAA**	NLAA	**LAA**	-	**LAA**	NLAA	NLAA	NLAA
Elkhorn coral	**LAA**	NLAA	-	-	NLAA	-	-	NLAA	NLAA	-	NLAA	-	**LAA**	NLAA	**LAA**	-	**LAA**	-	NLAA	NLAA
Staghorn coral	**LAA**	NLAA	-	-	NLAA	-	-	NLAA	NLAA	-	NLAA	-	**LAA**	NLAA	**LAA**	-	**LAA**	-	NLAA	NLAA
Pillar coral	**LAA**	NLAA	-	-	NLAA	-	-	NLAA	NLAA	-	NLAA	-	**LAA**	NLAA	**LAA**	-	**LAA**	-	NLAA	NLAA
Rough cactus coral	**LAA**	NLAA	-	-	NLAA	-	-	NLAA	NLAA	-	NLAA	-	**LAA**	NLAA	**LAA**	-	**LAA**	-	NLAA	NLAA
Lobed star coral	**LAA**	NLAA	-	-	NLAA	-	-	NLAA	NLAA	-	NLAA	-	**LAA**	NLAA	**LAA**	-	**LAA**	-	NLAA	NLAA
Mountainous star coral	**LAA**	NLAA	-	-	NLAA	-	-	NLAA	NLAA	-	NLAA	-	**LAA**	NLAA	**LAA**	-	**LAA**	-	NLAA	NLAA
Boulder star coral	**LAA**	NLAA	-	-	NLAA	-	-	NLAA	NLAA	-	NLAA	-	**LAA**	NLAA	**LAA**	-	**LAA**	-	NLAA	NLAA
Critical Habitat																				
Loggerhead – Northwest Atlantic DPS	NLAA	NLAA	-	-	NLAA	-	NLAA	NLAA	-	-	-	-	-	-	-	-	-	-	-	-
Atlantic sturgeon	NLAA	NLAA	-	-	NLAA	-	-	-	-	-	NLAA	NLAA	NLAA	NLAA	-	-	-	-	-	-
Gulf sturgeon	NLAA	-	-	-	-	-	-	NLAA	-	-	-	-	-	NLAA	-	-	-	-	-	-
Elkhorn and Staghorn	**LAA**	-	-	-	-	-	-	NLAA	-	-	NLAA	-	**LAA**	NLAA	**LAA**	-	**LAA**	-	-	-

9.1 Stressors Not Likely to Adversely Affect ESA-listed Resources

Our analysis of the stressors associated with the proposed action led to the determination that some stressors are not likely to adversely affect some or all ESA-listed resources because the effect of that stressor would be insignificant or discountable. The following section discusses stressors that are not likely to adversely affect some or all ESA-listed resources considered in this opinion. Note that discussion in this section is organized by taxa (i.e., marine mammals, sea turtles, fishes, corals) because the pathways for effects for these stressors is generally the same by taxa and we would not expect different effects at the species level. While there is variation among species within each taxa, the species within each taxa share many similar life history patterns and other factors (e.g., morphology) which make them similarly vulnerable (or not) to the stressors associated with the proposed action.

9.1.1 Marine Mammals

We determined that several of the acoustic stressors, all of the energy stressors, entanglement stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect ESA-listed blue, fin, Gulf of Mexico subspecies Bryde's, North Atlantic right, sei, and sperm whales. Our analysis for these stressors and marine mammals is summarized below.

9.1.1.1 Acoustic Stressors – Marine Mammals

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. NMFS determined that these acoustic stressors are not likely to adversely affect ESA-listed marine mammals. The effects of additional acoustic stressors, which NMFS determined are likely to adversely affect marine mammals, are discussed in Section 9.2.1.

9.1.1.1.1 Vessel Noise – Marine Mammals

Additional discussion on vessel noise as a potential stressor is included in Section 6.1.1. Navy vessel movements involve transits to and from ports to various locations within the action area, and many proposed activities within the action area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels), as well as unmanned vehicles. Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to two weeks. A study of Navy vessel traffic found that traffic was heaviest just offshore of Norfolk and Jacksonville, as well as along the coastal waters between the two ports (Mintz 2012b; Mintz and Filadelfo 2011b). During training, vessel speeds generally range from 10 to 14 knots. However, vessels can and will, on occasion, go faster if needed. While the discussion below focuses on the potential effects of vessel noise on marine mammals, it should be noted up front that it is often difficult to differentiate between the influence of sound exposure from vessels and the physical presence of vessels (e.g., Ng and Leung 2003).

Sound emitted from large vessels, such as cargo ships, is the principal source of low-frequency noise in the ocean today, and marine mammals are known to react to or be affected by that noise (Hatch and Wright 2007; Hildebrand 2005; Richardson et al. 1995e). For example, Erbe et al.

(2012) estimated the maximum annual underwater SEL from vessel traffic near Seattle was 215 dB re 1 μPa^{2}s, and Bassett et al. (2010) measured mean SPLs at Admiralty Inlet from commercial shipping at 117 dB re 1 μPa with a maximum exceeding 135 dB re 1 μPa on some occasions. Similarly, Veirs et al. (2015) found average broadband noise levels in Haro Strait to be 110 dB re 1 μPa that extended up to 40 kHz, well into the hearing range of odontocetes.

Cargo ships, bulk carriers and tankers account for almost two-thirds of commercial vessel traffic in the action area (Mintz 2012b). Annual commercial vessel traffic in the action area was estimated to be almost 10 million hours in 2009, compared to just over 70,000 hours for Navy vessel traffic, which was generally concentrated along the U. S. East Coast between Jacksonville and the Chesapeake Bay (Mintz 2012b).

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

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

The likelihood of response may be driven by the distance or speed of the vessel, the animal's behavioral state, or by the prior experience of the individual or population. For example, in one study fin and humpback whales largely ignored vessels that remained 100 m or more away (Watkins 1981a). In another study, minke whales in the Antarctic did not show any apparent response to a survey vessel moving at normal cruising speeds (about 12 knots) at a distance of 5.5 NM. However, when the vessel drifted or moved at very slow speeds (about 1 knot), many whales approached it (Leatherwood et al. 1982). Similarly, Bernasconi et al. (2012) observed the reactions of six individual baleen whales of unidentified species at distances of 50 to 400 m from a fishing vessel conducting an acoustic survey of pelagic fisheries, with only a slight change in swim direction when the vessel began moving around the whales. Sei whales have been observed ignoring the presence of vessels entirely and even passing close to vessels (Reeves et al. 1998), and North Atlantic right whales tend not to respond to the sounds of oncoming vessels and continue to use habitats in high vessel traffic areas (Nowacek et al. 2004). Studies show that

North Atlantic right whales demonstrate little if any reaction to sounds of vessels approaching or the presence of the vessels themselves. This lack of response may be due to habituation to the presence and associated noise of vessels in right whale habitat, or may be due to propagation effects that may attenuate vessel noise near the surface (Nowacek et al. 2004; Terhune and Verboom 1999).

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

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

The long-term consequences of vessel noise are not well understood. In a short-term study, minke whales on feeding grounds in Iceland responded to increased whale watching vessel traffic with a decrease in foraging, both during deep dives and at the surface (Christiansen et al. 2013). They also increased their avoidance of the boats while decreasing their respiration rates, likely leading to an increase in their metabolic rates. Christiansen and Lusseau (2015) followed up this study by modeling the cumulative impacts of whale watching boats on minke whales, but found that although the boats cause temporary feeding disruptions, there were not likely to be long-term consequences as a result. This suggests that short-term responses may not lead to long-term consequences, and that over time animals may habituate to the presence of vessel traffic. Using historical records, Watkins (1986) showed that the reactions of four species of mysticetes to vessel traffic and whale watching activities in Cape Cod had changed over the 25-year period examined (1957–1982). Reactions of minke whales changed from initially more positive reactions, such as coming towards the boat or research equipment to investigate, to more uninterested reactions towards the end of the study. Fin whales, the most numerous species in the area, showed a trend from initially more negative reactions, such as swimming away from the boat with limited surfacing, to more uninterested (ignoring) reactions allowing boats to approach within 30 m. Right whales showed little change over the study period, with a roughly equal number of reactions judged to be negative and uninterested; no right whales were noted as having positive reactions to vessels. Humpback whales showed a trend from negative to positive reactions with vessels during the study period. The author concluded that the whales had habituated to the human activities over time (Watkins 1986b).

Overall baleen whale responses to vessel noise and traffic are varied but are generally minor, and habituation or disinterest seems to be the predominant long-term response. If baleen whales do avoid ships, they do so by altering their swim and dive patterns to move away from the vessel, but no strong reactions have been observed. In many cases, whales do not appear to change their behavior at all. This may result from habituation by the whales, but may also result from reduced received levels near the surface due to propagation, or due to acoustic shadowing of the propeller cavitation noise by the ship’s hull.

Most odontocetes react neutrally to vessels, although both avoidance and attraction behavior have been observed (Hewitt 1985; Wursig et al. 1998a). Wursig et al. (1998a) found that Kogia whales and beaked whales were the most sensitive species to vessels, and reacted by avoiding marine mammal survey vessels in 73 percent of sightings, more than any other odontocetes. Avoidance reactions included a decrease in resting behavior or change in travel direction (Bejder et al. 2006a). Incidents of attraction have also been observed in odontocetes (e.g., Wursig et al. 1998a). A study of vessel reactions by dolphin communities in the eastern tropical Pacific found that populations that were often the target of tuna purse-seine fisheries (spotted, spinner, and common dolphins) showed evasive behavior when approached; however, populations that lived closer to shore (within 100 NM; coastal spotted and bottlenose dolphins) that are not set on by purse-seine fisheries tend to be attracted to vessels (Archer et al. 2010). The presence of vessels has also been shown to interrupt feeding behavior in delphinids (Meissner et al. 2015; Pirotta et al. 2015b).

Short-term displacement of dolphins due to tourist boat presence has been documented (Carrera et al. 2008), while longer term or repetitive/chronic displacement for some dolphin groups due to chronic vessel noise has been noted (Haviland-Howell et al. 2007). Delphinid behavioral states also change in the presence of tourist boats that often approach animals, with travel increasing and foraging decreasing (Meissner et al. 2015). Most studies of the behavioral reactions to vessel traffic of bottlenose dolphins have documented at least short-term changes in behavior, activities, or vocalization patterns when vessels are near, although the distinction between vessel noise and vessel movement has not been made clear (e.g., Gregory and Rowden 2001; Mattson et al. 2005). Steckenreuter et al. (2011) found bottlenose dolphin groups to feed less, become more tightly clustered, and have more directed movement when approached to 50 m than groups approached to 150 m or approached in a controlled manner. Guerra et al. (2014) demonstrated that bottlenose dolphins subjected to chronic noise from tour boats responded to boat noise by alterations in group structure and in vocal behavior but also found the dolphins' reactions varied depending on whether the observing research vessel was approaching or moving away from the animals being observed. This demonstrates that the influence of the sound exposure cannot be decoupled from the physical presence of a surface vessel, thus complicating interpretations of the relative contribution of each stimulus to the response. Indeed, the presence of surface vessels, their approach, and speed of approach seemed to be significant factors in the response of the Indo-Pacific humpback dolphins (Ng and Leung 2003).

Vessels have been shown to affect killer whales as well, such as the Northern and Southern Resident populations on the west coast of North America. These animals are targeted by numerous small whale-watching vessels in the Pacific Northwest and, from 1998 to 2012 during the viewing season, had an annual monthly average of nearly 20 vessels of various types within 0.5 mile of their location during daytime hours (Erbe et al. 2014). These vessels have source levels that ranged from 145 to 169 dB re 1 μPa and produce broadband noise up to 96 kHz and 116 dB re 1 μPa. They have the potential to result in behavioral disturbance, interfere with communication, and affect the killer whales' hearing capabilities via masking (Erbe 2002; Veirs et al. 2015). Killer whales foraged significantly less and traveled significantly more when boats were within 100 m of the whales (e.g., Lusseau et al. 2009; Williams et al. 2002a). These short-term feeding activity disruptions may have important long-term population-level effects (Lusseau et al. 2009; Noren et al. 2009). As with other delphinids, the reaction of the killer whales to whale-watching vessels may be in response to the vessel pursuing them rather than to the noise of the vessel itself, or to the number of vessels in their proximity. Williams et al. (2014) modeled behavioral responses of killer whales to vessel traffic by looking at their surface behavior relative to the received sound level of three large classes of ships. The authors found that the severity of the response was largely dependent on seasonal data (e.g., year and month) as well as the animal's prior experience with vessels (e.g., age and sex), and the number of other vessels present, rather than the received level of the larger ships (Williams et al. 2014).

Sperm whales, the only ESA-listed odontocete in the action area, generally react only to vessels approaching within several hundred meters. However, some individuals may display avoidance behavior, such as quick diving (Magalhaes et al. 2002; Wursig et al. 1998a) or a decrease in time spent at the surface (Isojunno and Miller 2015). One study showed that after diving, sperm whales showed a reduced timeframe before they emitted the first click than prior to a vessel interaction (Richter et al. 2006). Smaller whale watching and research vessels generate more noise in higher-frequency bands and are more likely to approach odontocetes directly, and to spend more time near an individual whale. Azzara et al. (2013) also found a reduction in sperm whale clicks while a vessel was passing, as well as up to a half hour after the vessel had passed. It is unknown whether the whales left the area, ceased to click, or surfaced during this period.

Some odontocetes have been shown to make short-term changes to vocal parameters such as intensity as an immediate response to vessel noise, as well as increase the pitch, frequency modulation, and length of whistling (May-Collado and Wartzok 2008). For example, bottlenose dolphins in Portuguese waters decreased their call rates and changed the frequency parameters of whistles in the presence of boats (Luis et al. 2014), while dolphin groups with calves increased their whistle rates when tourist boats were within 200 m and when the boats increased their speed (Guerra et al. 2014). Likewise, modification of multiple vocalization parameters was shown in belugas residing in an area known for high levels of commercial traffic. These animals decreased their call rate, increased certain types of calls, and shifted upward in frequency content in the presence of small vessel noise (Lesage et al. 1999). Another study detected a measurable increase in the amplitude of their vocalizations when ships were present (Scheifele et al. 2005). Killer whales are also known to modify their calls during increased noise. For example, the source level of killer whale vocalizations was shown to increase with higher background noise levels associated with vessel traffic (the Lombard effect) (Holt et al. 2008). In addition, calls with a high-frequency component have higher source levels than other calls, which may be related to behavioral state, or may reflect a sustained increase in background noise levels (Holt et al. 2011a). On the other hand, long-term modifications to vocalizations may be indicative of a learned response to chronic noise, or of a genetic or physiological shift in the populations. This type of change has been observed in killer whales off the northwestern coast of the United States between 1973 and 2003. This population increased the duration of primary calls once a threshold in observed vessel density (e.g., whale watching) was reached, which is suggested as being a long-term response to increased masking noise produced by the vessels (Foote et al. 2004a).

The long-term and cumulative implications of ship sound on odontocetes is largely unknown, although some long-term consequences have been reported (Higham et al. 2007). Repeated exposure to acoustic and other anthropogenic stimuli has been studied in several cases, especially as related to vessel traffic and whale watching. Common dolphins in New Zealand responded to dolphin-watching vessels by interrupting foraging and resting bouts, and took longer to resume behaviors in the presence of the vessel (Stockin et al. 2008). The authors suggested that repeated interruptions of the dolphins' foraging behaviors could lead to long-term implications for the population. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found stronger and longer lasting reactions in populations of animals that were exposed to lower levels of vessel traffic overall. The authors indicated that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Similar to mysticetes, odontocete responses to vessel noise are varied. Some species, in particular killer whales and porpoises, may be sensitized to vessels and respond at further distances and lower received levels than other delphinids. In contrast, many odontocete species also approach vessels to bowride, indicating either that these species are less sensitive to vessels, or that the behavioral drive to bowride supersedes any impact of the associated noise.

Marine mammals may also experience masking due to vessel noises. For example, right whales were observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007a) as well as increasing the amplitude (intensity) of their calls (Parks et al. 2011a; Parks et al. 2009). Right whales also had their communication space reduced by up to 84 percent in the presence of vessels (Clark et al. 2009a). Although humpback whales did not change the frequency or duration of their vocalizations in the presence of ship noise, their source levels were lower than expected, potentially indicating some signal masking (Dunlop 2016).

Vessel noise can potentially mask vocalizations and other biologically important sounds (e.g., sounds of prey or predators) that marine mammals may rely on. Potential masking can vary depending on the ambient noise level within the environment, the received level and frequency of the vessel noise, and the received level and frequency of the sound of biological interest. In the open ocean, ambient noise levels are between about 60 and 80 dB re 1 μPa in the band between 10 Hz and 10 kHz due to a combination of natural (e.g., wind) and anthropogenic sources (Urick 1983a), while inshore noise levels, especially around busy ports, can exceed 120 dB re 1 μPa. When the noise level is above the sound of interest, and in a similar frequency band, masking could occur. This analysis assumes that any sound that is above ambient noise levels and within an animal's hearing range may potentially cause masking. However, the degree of masking increases with increasing noise levels; a noise that is just detectable over ambient levels is unlikely to cause any substantial masking.

The ESA-listed marine mammals considered in this opinion will be exposed to noise from Navy vessels during training and testing activities in the action area. As documented above, vessel noise has the potential to disturb marine mammals and elicit an alerting, avoidance, or other behavioral reaction. These reactions are anticipated to be short-term, likely lasting the amount of time the vessel and the whale are in close proximity (e.g., Magalhaes et al. 2002; Richardson et al. 1995d; Watkins 1981a), and not consequential to the animals. Additionally, short-term masking could occur. Masking by passing ships or other sound sources transiting the action area would be short term and intermittent, and therefore unlikely to result in any substantial costs or consequences to individual animals or populations. Areas with increased levels of ambient noise from anthropogenic noise sources such as areas around busy shipping lanes and near harbors and ports may cause sustained levels of masking for marine mammals, which could reduce an animal's ability to find prey, find mates, socialize, avoid predators, or navigate. Navy vessels make up a very small percentage of the overall traffic in the action area (two orders of magnitude lower than commercial ship traffic in the action area), so Navy vessels are not expected to significantly contribute to overall background levels of underwater noise in the marine environment. This minimizes the potential for Navy vessels to contribute to long-term masking in the action area.

In summary, ESA-listed marine mammals are either not likely to respond to vessel noise or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering. Therefore, the effects of vessel noise on ESA-listed marine mammals are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Additionally, the effects of any temporary masking specifically from Navy vessels is insignificant given the background noise levels in the action area independent of Navy vessels and the small percentage of vessel traffic Navy vessels represent in the action area.

9.1.1.1.2 Aircraft Overflight Noise – Marine Mammals

Additional discussion of aircraft overflight noise as a potential stressor is included in Section 6.1.2. Aircraft overflights will usually occur near Navy airfields, installations, and in special use airspace within Navy range complexes. Aircraft flights during training would be most concentrated within the Virginia Capes, Navy Cherry Point, Jacksonville, and Key West Range Complexes.

Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors, but significant acoustic energy is primarily transmitted into the water directly below the craft in a narrow cone (Navy 2017a). Underwater sounds from aircraft are strongest just below the surface and directly under the aircraft. Marine mammals may respond to both the physical presence and to the noise generated by aircraft, making it difficult to attribute causation to one or the other stimulus. In addition to noise produced, all low-flying aircraft make shadows, which can cause animals at the surface to react. Helicopters may also produce strong downdrafts, a vertical flow of air that becomes a surface wind, which can also affect an animal's behavior at or near the surface.

The following paragraphs summarize what is known about the reaction of various marine mammal species to overhead flights of many types of fixed-wing aircraft and helicopters, as well as unmanned aerial vehicles. Thorough reviews of the subject and available information is presented in Richardson et al. (1995e) and elsewhere (e.g., Efroymson et al. 2001; Holst et al. 2011; Luksenburg and Parsons 2009; Smith et al. 2016). The most common responses of cetaceans to overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping; Nowacek et al. 2007). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Holst et al. 2011; Manci et al. 1988). Richardson et al. (1995e) noted that marine mammal reactions to aircraft overflights have largely consisted of opportunistic and anecdotal observations lacking clear distinction between reactions potentially caused by the noise of the aircraft and the visual cue an aircraft presents. In addition, it was suggested that variations in the responses noted were generally due to other undocumented factors associated with overflights (Richardson et al. 1995e). These factors could include aircraft type (single engine, multi-engine, jet turbine), flight path (altitude, centered on the animal, off to one side, circling, level and slow), environmental factors (e.g., wind speed, sea state, cloud cover) and locations where native subsistence hunting continues and animals are more sensitive to anthropogenic impacts, including the noise from aircraft. Christiansen et al. (2016a) measured the in air and underwater noise levels of two unmanned aerial vehicles. The researchers found that in air the broadband source levels were around 80 dB re 20 μPa, while at a meter underwater received levels were 95 to 100 dB re 1 μPa when the vehicle was only 5 to 10 m above the surface, and were not quantifiable above ambient noise levels when the vehicle was higher. Therefore, if an animal is near the surface and the unmanned aerial vehicle is flying at a low altitude, it may be detected, but in most cases these vehicles are operated at much higher altitudes (e.g. well over 30 m) and so are not likely to be heard.

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

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

Bowhead whales in the Beaufort Sea exhibited a transient behavioral response to fixed-wing aircraft and vessels. Reactions were frequently observed at less than 1,000 ft (304.8 m) above sea level, infrequently observed at 1,500 ft (457.2 m), and not observed at all at 2,000 ft (609.6 m) (Richardson et al. 1985a). Bowhead whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns. Behavioral reactions decreased in frequency as the altitude of the helicopter increased to 150 m or higher. The bowheads exhibited fewer behavioral changes than did the odontocetes in the same area (Patenaude et al. 2002). It should be noted that bowhead whales in this study may have more acute responses to anthropogenic activity than many other marine mammals because these animals were presented with restricted egress due to limited open water between ice floes.

Additionally, these animals are hunted by Alaska Natives, which could lead to animals developing additional sensitivity to human noise and presence.

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

Variable responses to aircraft have been observed in toothed whales, though overall little change in behavior has been observed during flyovers. Some toothed whales dove, slapped the water with their flukes or flippers, or swam away from the direction of the aircraft during overflights; others did not visibly react Richardson et al. (1995d). Wursig et al. (1998a) found that beaked whales were the most sensitive cetacean and reacted by avoiding marine mammal survey aircraft in 89 percent of sightings and at more than twice the rate as Kogia whales, which was the next most reactive of the odontocetes in 39 percent of sightings. These are the same species that were sensitive to vessel traffic.

During standard marine mammal surveys at an altitude of 750 ft, some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after being sighted. Other authors have corroborated the variability in sperm whales' reactions to fixed-wing aircraft or helicopters (Richter et al. 2006; Richter et al. 2003a; Smultea et al. 2008; Wursig et al. 1998a). In one study, sperm whales showed no reaction to a helicopter until they encountered the downdrafts from the rotors (Richardson et al. 1995e). A group of sperm whales responded to a circling aircraft (altitude of 800 to 1,100 ft) by moving closer together and forming a defensive fan-shaped semicircle, with their heads facing outward. Several individuals in the group turned on their sides, apparently to look up toward the aircraft (Smultea et al. 2008). Whale-watching aircraft (fixed-wing airplanes and helicopters) apparently caused sperm whales to turn more sharply but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al. 2003b).

Smaller delphinids generally react to overflights either neutrally or with a startle response (Wursig et al. 1998a). Beluga whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns to a greater extent than mysticetes in the same area (Patenaude et al. 2002). These reactions increased in frequency as the altitude of the helicopter dropped below 150 m. A change in travel direction was noted in a group of pilot whales as the aircraft circled while conducting monitoring (HDR 2011).

Much like mysticetes, odontocetes have demonstrated no responses to unmanned aerial vehicles. For example, Durban et al. (2015) conducted photogrammetry studies of killer whales using a small hexacopter flown 35 to 40 m above the animals with no disturbance noted. However, odontocete responses may increase with reduced altitude, due either to noise or the shadows created by the vehicle (Smith et al. 2016).

It should be noted that many of the observations cited in this section are of marine mammal reactions to aircraft flown for whale-watching and marine research purposes. Marine mammal survey aircraft are typically used to locate, photograph, track, and sometimes follow animals for long distances or for long periods of time, all of which results in the animal being much more frequently located directly beneath the aircraft (in the cone of the loudest noise and potentially in the shadow of the aircraft) for extended periods. In contrast to whale-watching excursions or research efforts, Navy aircraft would not follow marine mammals so would not result in prolonged exposure of marine mammals to overhead noise or encroachment.

To summarize, in most cases, exposure of a marine mammal to fixed-wing aircraft, helicopters, and unmanned aircraft presence and noise would last for only seconds as the aircraft quickly passes overhead. Animals would have to be at or near the surface at the time of an overflight to be exposed to appreciable sound levels. Takeoffs and landings occur at established airfields as well as on vessels at sea at unspecified locations across the action area. Takeoffs and landings from Navy vessels could startle marine mammals. However, these events only produce in-water noise at any given location for a brief period as the aircraft climbs to cruising altitude. Some sonic booms from aircraft could startle marine mammals, but these events are transient and happen infrequently at any given location within the action area. Repeated exposure to most individuals over short periods (days) is extremely unlikely, except for animals that are resident in inshore areas around Navy ports, on Navy fixed ranges (e.g., the Undersea Warfare Training Range), or during major training exercises. Resident animals could be subjected to multiple overflights per day, though the ESA-listed species considered in this opinion have wide ranging life histories. Additionally, aircraft would pass quickly overhead, typically at altitudes above 3,000 ft, which would make marine mammals unlikely to respond. Due to the short term and infrequent nature of any exposures to fixed-wing and unmanned aircraft flight and the brief responses that could follow such exposure, the effects of fixed-wing aircraft overflight on ESA-listed marine mammals is insignificant.

Low flight altitudes of helicopters during some anti-submarine warfare and mine warfare activities, often under 100 ft, may elicit a somewhat stronger behavioral response due to the proximity to marine mammals, the slower airspeed and therefore longer exposure duration, and the downdraft created by the helicopter's rotor. Marine mammals would likely avoid the area under the helicopter due to the downdraft, noise, and presence of the helicopter. It is unlikely that an individual would be exposed repeatedly for long periods because these aircraft typically transit open ocean areas within the action area. The literature cited above indicates that aircraft noise would cause only small temporary changes in the behavior of marine mammals. Specifically, marine mammals at or near the surface when an aircraft flies overhead at low altitude may startle, divert their attention to the aircraft, or avoid the immediate area by swimming away or diving.

In summary, due to the short-term nature of any exposures to aircraft and the brief responses that could follow such exposure, the effects of aircraft overflight noise on ESA-listed marine mammals are insignificant (i.e., so minor that the effects cannot be meaningfully evaluated).

9.1.1.1.3 Noise from Weapons – Marine Mammals

Activities using weapons and deterrents would be conducted as described in Section 3.3 of this opinion. Additional discussion on weapons noise as a potential stressor is included in Section 6.1.4. Use of weapons during training could occur almost anywhere within the action area, with greatest use of most types of munitions in the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes. Noise associated with large caliber weapons firing and the impact of non-explosive practice munitions or kinetic weapons would typically occur at locations greater than 12 NM from shore for safety reasons. Small- and medium-caliber weapons firing could occur throughout the action area.

A gun fired from a ship on the surface of the water propagates a blast wave away from the gun muzzle into the water. Yagla and Stiegler (2003b) found that the average peak sound pressure in the water measured directly below the muzzle of the gun and under the flight path of the shell (assuming it maintains an altitude of only a few meters above the water's surface) was approximately 200 dB re 1 μPa. Animals at the surface of the water, in a narrow footprint under a weapons trajectory, could be exposed to naval gunfire noise and may exhibit brief startle reactions, avoidance, diving, or no reaction at all. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange. These sounds would be transient and of short duration, lasting no more than a few seconds at any given location. Many missiles are launched from aircraft, which would produce minimal noise in the water due to the altitude of the aircraft at launch. Missiles and targets launched by ships or near the water's surface may expose marine mammals to levels of sound that could produce brief startle reactions, avoidance, or diving. Some objects, such as hyperkinetic projectiles and non-explosive practice munitions, could impact the water with great force and produce a relatively large impulse.[21] Animals within the area may hear the impact of non-explosive ordnance on the surface of the water and would likely alert, startle, dive, or avoid the immediate area.

For noise produced by each of these different types of weapons, behavioral reactions would likely be short-term (minutes) and due to the short-duration, transient nature of launch noise, animals are unlikely to be exposed multiple times within a short period. For these reasons, the

[21] Note that the potential for objects to physically strike an ESA-listed marine mammal is discussed in section 9.1.1.4.

effects of weapon noise on ESA-listed marine mammals are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.1.1.4 Air Guns – Marine Mammals

Additional discussion of air guns as a potential stressor is included in Section 6.1.5. Air guns would only be using during testing activities and would be fired 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. It is important to point out that many observations of marine mammal reactions to air guns are from oil and gas exploration activities that use large air gun arrays and operate continuously for multiple weeks to cover large areas of the ocean. In contrast, Navy activities only use single air guns over a much shorter period and within a limited area. Reactions to single air guns, which are used in a limited fashion, are less likely to be of the same severity. Potential impacts could include temporary hearing loss, behavioral reactions, physiological stress and masking, depending on the level of exposure anticipated. The approach, as well as the criteria and thresholds, used to determine the potential extent of exposure of marine mammals to air guns is described in Section 2.2.

Table 64 below presents the range to effects from air guns for 10 pulses and Table 65 presents the range to effects from air guns for 100 pulses.

Table 64. Range to effects from air guns for 10 pulses (Navy 2017a).

Range to Effects for Air guns[1] for 10 pulses (m)					
Hearing Group	PTS (SEL)	PTS (Peak SPL)	TTS (SEL)	TTS (Peak SPL)	Behavioral[2]
Low-Frequency Cetacean	13 (12—13)	2 (2—2)	72 (70—80)	4 (4—4)	685 (170—1,025)
Mid-Frequency Cetacean	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)	680 (160—2,275)

[1] *Average distance (m) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses.*
[2] *Behavioral values depict the ranges produced by RMS hearing threshold criteria levels.*

Table 65. Range to effects from air guns for 100 pulses (Navy 2018a).

Range to Effects for Air guns[1] for 100 pulses (m)					
Hearing Group	PTS (SEL)	PTS (Peak SPL)	TTS (SEL)	TTS (Peak SPL)	Behavioral[2]
Low-Frequency Cetacean	122 (120—130)	3 (3—3)	871 (600—1,275)	13 (12—13)	2,546 (1,025 – 5,525)
Mid-Frequency Cetacean	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)	2,546 (1,025 – 5,525)

[1] Average distance (m) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses.
[2] Behavioral values depict the ranges produced by RMS hearing threshold criteria levels.

Based on the Navy's NAEMO modeling, fin whales and the Gulf of Mexico subspecies of Bryde's whale could be exposed to sounds from air guns. However, these exposures are not expected to rise to the level of injury or significant behavioral changes (i.e., will not exceed the thresholds described in Section 2.2). For this reason, the potential effect of air guns on fin whales and the Gulf of Mexico subspecies of Bryde's whale is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). The other ESA-listed large whale species in the action area (i.e., blue, fin, sei, sperm, North Atlantic right whale) could also be exposed, though based on the Navy's modeling, exposure is extremely unlikely. Therefore, the potential effects of air guns on these species are discountable.

9.1.1.1.5 Pile Driving – Marine Mammals

Pile driving will be required to construct a temporary elevated causeway, as described in Section 6.1.6. Activities with pile driving would take place nearshore and within the surf zone up to two times per year, once at Joint Expeditionary Base Little Creek/Fort Story, Virginia, and once at Marine Corps Base Camp Lejeune, North Carolina.

Similar to air guns, impact hammer pile driving produces an impulsive, broadband sound, primarily in low-frequency ranges. As such, it is within the hearing ranges of marine mammals. Vibratory hammers produce a non-impulsive, continuous sound. Potential effects of underwater sound from pile driving on marine mammals include injury, threshold shift, and behavioral disturbance (e.g., Nowacek et al. 2007; Richardson et al. 1995e; Southall et al. 2007c). These effects are similar to what is described in detail later for marine mammals in response to other acoustic stressors (e.g., See Sections 9.2.1.1.1 and 9.2.1.2.1). One of the primary differences between pile driving and other Navy acoustic stressors is that pile driving is a stationary source whereas most other Navy acoustic stressors move.

Pile driving for the Elevated Causeway System training would occur in shallow water with soft substrates. In general, softer substrates absorb the sound better than hard substrates, thus, pile driving in softer substrates does not typically produce the louder sound signals that driving in hard substrate would. Soft, wetted substrates, may increase ground-borne transmission, meaning a sound wave could propagate further away from the source through the substrate. If ground-borne transmission sound reenters the water column, the intensity and amplitude of the sound wave would likely be lower than the sound wave traveling from the source through the water column and not likely to cause injury but could result in disturbance.

Some ESA-listed cetaceans have the potential to occur in the vicinity of Navy impact pile driving activities and could be exposed to elevated underwater sound. The Navy's quantitative modeling indicated that fin and North Atlantic right whales may be exposed to noise from pile driving activities associated with the construction and removal of the elevated causeway system, though no exposures were modeled that exceeded the impact thresholds for these species.

The Navy will implement measures that will decrease the likelihood of pile driving activities resulting in adverse impacts to ESA-listed marine mammals. Due to pile driving system design and operation, the Navy performs soft starts during impact installation of each pile to ensure proper operation of the diesel impact hammer. During a soft start, the Navy performs an initial set of strikes from the impact hammer at reduced energy before it can be operated at full power and speed. This standard operating procedure may "warn" marine mammals and cause them to move away from the sound source before impact pile driving increases to full operating capacity. This would be expected to reduce their exposure to higher levels of individual pile strikes thereby reducing their cumulative sound exposure level. The Navy will also implement a 100 yard mitigation zone around the pile driving activity which would prevent any animals from coming in close proximity to pile driving activities (i.e., within 100 yards). Also important to consider is the high sightability of baleen whales (i.e., median sighting distance of 600 meters from the source according to Barkaszi et al. 2012), particularly in the shallow water areas where pile driving is conducted, indicating the Navy lookouts are likely to detect any ESA-listed marine mammals in close proximity to the pile driving activity and implement a delay or shutdown of the activity until the animal leaves the area.

In summary, based on the measures described above that will decrease the likelihood of pile driving activities resulting in adverse impacts to fin and North Atlantic right whales, the shallow water nearshore environment with soft substrates where the activity will be conducted, the relatively low densities of these species in the areas where pile driving activities will occur (Navy 2017e), and the Navy's modeling results that indicated no exposures of these species even out to the behavioral harassment threshold (i.e., 870 m), it is extremely unlikely that fin or North Atlantic right whales will experience PTS, TTS, or a significant behavioral disruption due to Navy pile driving activities. For these reasons, the likelihood of North Atlantic right and fin whales being exposed to sound from Navy pile driving activities that could result in non-auditory injury, PTS, TTS, or behavioral harassment is discountable.

9.1.1.2 Energy Stressors – Marine Mammals

This section analyzes the potential impacts of energy stressors used during training and testing activities within the action area. Additional discussion on energy stressors is included in Section 6.3. This section includes analysis of the potential impacts of: (1) in-water electromagnetic devices and (2) high-energy lasers.

9.1.1.3 In-water Electromagnetic Devices – Marine Mammals

The devices producing an electromagnetic field are towed or unmanned mine countermeasure systems. The electromagnetic field is produced to simulate a vessel's magnetic field. In an actual mine-clearing operation, the intent is that the electromagnetic field would trigger an enemy mine designed to sense a vessel's magnetic field.

Normandeau et al. (2011b) concluded there was behavioral, anatomical, and theoretical evidence indicating cetaceans sense magnetic fields. Fin, humpbacks, and sperm whales have shown positive correlations with geomagnetic field differences. Although none of the studies have determined the mechanism for magneto-sensitivity, the suggestion from these studies is that whales can sense the Earth's magnetic field and may use it to migrate long distances. Cetaceans appear to use the Earth's magnetic field for migration in two ways: as a map by moving parallel to the contours of the local field topography, and as a timer based on the regular fluctuations in the field allowing animals to monitor their progress on this map (Klinowska 1990).

Most of the evidence of cetaceans sensing magnetic fields is indirect evidence from correlation of sighting and stranding locations suggesting that cetaceans may be influenced by local variation in the earth's magnetic field (Kirschvink 1990b; Klinowska 1985; Walker et al. 1992). Results from one study in particular showed that long-finned and short-finned pilot whales, striped dolphin, Atlantic spotted dolphin, Atlantic white-sided dolphin, fin whale, common dolphin, harbor porpoise, sperm whale, and pygmy sperm whale were found to strand in areas where the earth's magnetic field was locally weaker than surrounding areas (negative magnetic anomaly; (Kirschvink 1990a). Results also indicated that certain species may be able to detect total intensity changes of only 0.05 microteslas (Kirschvink et al. 1986). This gives insight into what changes in intensity levels some species are capable of detecting, but does not provide experimental evidence of levels to which animals may physiologically or behaviorally respond. Further, not all physiological or behavioral responses are biologically significant and rise to the level of take as defined in the ESA.

Impacts to marine mammals associated with electromagnetic fields are dependent on the animal's proximity to the source and the strength of the magnetic field. Electromagnetic fields associated with naval training exercises and testing activities are relatively weak (only 10 percent of the earth's magnetic field at 24 m), temporary, and localized. Once the source is turned off or moves from the location, the electromagnetic field is gone. A marine mammal would have to be present within the electromagnetic field (approximately 200 m from the source) during the activity in order to detect it, though detection does not necessarily signify a significant biological response rising to the level of take as defined under the ESA. Given the small area associated with mine fields, the infrequency and short duration of magnetic energy use, the low intensity of electromagnetic energy sources (essentially mimicking the magnetic field of a steel vessel), the density of cetaceans in these areas, and the Navy's procedural mitigation measure to not approach ESA-listed cetaceans within 500 yards (Table 34), NMFS considers it extremely unlikely that ESA-listed marine mammals would be exposed to electromagnetic energy at sufficient intensities to create an adverse effect through behavioral disruption or otherwise. Therefore, potential effects from electromagnetic devices are discountable.

9.1.1.3.1 Lasers – Marine Mammals

High-energy laser weapons activities involve evaluating the effectiveness of an approximately 30-kilowatt high-energy laser deployed from a surface ship or a helicopter to create small but critical failures in potential targets from short ranges. A marine mammal could be exposed to the laser beam at or near the water's surface, which could result in injury or death. However, marine mammals could only be exposed if the laser beam missed the target (i.e., if the laser hit the target, it would not be expected to penetrate the water and potentially impact a marine mammal underwater), which would not be expected to be common. Additionally, ESA-listed marine mammal densities in the action area are relatively low. The likelihood of a laser missing a target and striking a marine mammal at or near the surface of the water is remote. For example, the Navy conducted a probability analysis to determine the potential for marine mammals to be directly hit by a high-energy laser beam (Navy 2017c). The marine mammal species with the highest average seasonal density (short beaked common dolphin) in the location with the greatest number of training activities involving high-energy lasers (Virginia Capes Range Complex) was used as a surrogate for ESA-listed marine mammals in the statistical probability analysis. Even using this density, the likelihood that an individual would be struck by a laser was extremely low (i.e., probability of 0.000147). The probability of striking any ESA-listed marine mammal species was even lower (i.e., highest probability was 0.000012 for sperm whales). For these reasons, NMFS considers it extremely unlikely that ESA-listed marine mammals would be exposed to high energy lasers. Therefore, potential effects from lasers are discountable.

9.1.1.4 Physical Disturbance and Strike Stressors – Marine Mammals

Additional discussion on physical disturbance and strike stressors is included in Section 6.4. This section analyzes the potential impacts of the various types of physical disturbance, including the potential for strike, during training and testing activities within the action area from: in-water devices; military expended materials, including non-explosive practice munitions and fragments from high-explosive munitions; and seafloor devices. Vessel strike of cetaceans is discussed in Section 9.2.1.3.

9.1.1.4.1 In-water devices

In-water devices are used in both offshore and inshore areas of the action area. Despite thousands of Navy exercises in which in-water devices have been used, there have been no recorded instances of marine species strikes from these devices. The Navy will implement mitigation to avoid potential impacts from in-water device strikes on marine mammals throughout the action area. Mitigation includes using Lookouts and watch personnel that have been trained to identify marine mammals (See Section 3.4.2) and requiring underway vessels and in-water devices that are towed from manned surface platforms to maintain a specified distance from marine mammals

(See Section 3.4.2.1.16). For these reasons, NMFS considers it extremely unlikely for any ESA-listed marine mammal to be struck by an in-water device. It is possible that marine mammal species that occur in areas that overlap with in-water device use may experience some level of physical disturbance, but it is not expected to result in more than a momentary behavioral response. Any avoidance behavior would be of short duration and intensity such that it would be insignificant (i.e., so minor that the effect cannot be meaningfully evaluated) to the animal. Therefore, potential effects on ESA-listed marine mammals from in-water devices are discountable or insignificant.

9.1.1.4.2 Military Expended Materials

This section analyzes the strike potential to ESA-listed marine mammals from the following categories of military expended materials: (1) all sizes of non-explosive practice munitions, (2) fragments from high-explosive munitions, (3) expendable targets and target fragments, and (4) expended materials other than munitions, such as sonobuoys, expended bathythermographs, and torpedo accessories. While no strike of marine mammals from military expended materials has ever been reported or recorded, the possibility of a strike still exists. However, given the large geographic area involved and the relatively low densities of ESA-listed marine mammals in the action area, we do not believe such interactions are likely (or reasonably certain to occur). For example, the Navy conducted a probability analysis for each ESA-listed marine mammal to be struck by military expended materials while at the surface (Navy 2017c). A scenario was calculated using areas with the highest amounts of military expended material expenditures, specifically Virginia Capes and Jacksonville Range Complexes. Estimates were made for each of the ESA-listed marine mammal species found in the areas where the highest levels of military expended materials would be expected. The model output indicated that no ESA-listed marine mammal would be struck by military expended materials in the action area. Additionally, while disturbance or strike from any expended material as it falls through the water column is possible, it is not likely because the objects will slow in velocity as they sink toward the bottom (e.g., guidance wires sink at an estimated rate of 0.7 ft [0.2 m] per second; heavier items such as non-explosive munitions would likely sink faster, but would still be slowed as they sink to the bottom), and can be avoided by highly mobile organisms such as cetaceans. Also important in this conclusion is that animals are unlikely to encounter military expended materials falling through the water column due to the large geographic area involved and the relatively low densities of ESA-listed marine mammals in the action area.

In summary, NMFS considers it extremely unlikely for any ESA-listed marine mammal to be struck by military expended materials. Any individuals encountering military expended materials as they fall through the water column are likely to move to avoid them. Given the effort expended by individuals to avoid them will be minimal (i.e., a few meters distance) and temporary, behavioral avoidance of military expended materials sinking through the water column is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). For these reasons, potential effects on ESA-listed marine mammals from physical disturbance and strike with military expended materials are insignificant or discountable.

9.1.1.4.3 Seafloor Devices

Activities that use seafloor devices include items placed on, dropped on, or moved along the seafloor such as mine shapes, anchor blocks, anchors, bottom-placed devices, and bottom-crawling unmanned underwater vehicles. Seafloor devices are either stationary or move very slowly along the bottom and do not pose a threat to highly mobile organisms. Objects falling through the water column will slow in velocity as they sink toward the bottom and would be avoided by ESA-listed marine mammals. The only seafloor device used during training and testing activities that has the potential to strike an ESA-listed marine mammal at or near the surface is an aircraft deployed mine shape, which is used during aerial mine laying activities. These devices are identical to non-explosive practice bombs, and the analysis of the potential impacts from those devices are covered in the military expended material strike section. NMFS considers it extremely unlikely for any ESA-listed marine mammals to be struck by a seafloor device. Therefore, potential effects on ESA-listed marine mammals from seafloor device strike are discountable. Any individuals encountering seafloor devices are likely to behaviorally avoid them. Given the slow movement and relatively small size of seafloor devices, the effort expended by individuals to avoid them will be minimal and temporary, and will not have fitness consequences. Therefore, behavioral avoidance of seafloor devices by ESA-listed marine mammals is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.1.5 Entanglement Stressors – Marine Mammals

Additional discussion of entanglement stressors is included in Section 6.5. Some expended materials from U.S. Navy activities may pose a risk of entanglement to marine mammals in the action area. These interactions could occur at the sea surface, in the water column, or on the seafloor. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with military expended materials have the potential to result in negative sub-lethal effects, mortality, or result in no impact. Expended materials from Navy activities that may pose an entanglement risk include wires and cables, biodegradable polymers, and decelerators/parachutes. Though there is a potential for ESA-listed marine mammals to encounter military expended material, for the reasons described below, we do not believe such interactions are reasonably certain to occur.

There has never been a reported or recorded instance of a marine mammal entangled in military expended materials. NOAA (2014a) conducted a review of entanglement of marine species in marine debris with an emphasis on species in the United States. The review did not document any known instances where military expended material had entangled a cetacean. Instead, the vast majority of entanglements have been from actively fished or derelict fishing gear. For example, Knowlton et al. (2012a), as cited in NOAA (2014a), conducted a 30-year comprehensive review of entanglement rates of North Atlantic right whales using photographs.

In the report, 626 individuals were observed and the vast majority showed evidence of entanglement involving non-mobile pot gear and nets used for fishing. Military expended material has not been shown to entangle ESA-listed large whales despite the Navy expending materials in the action area (and other range complexes) for decades.

If encountered, it is unlikely that an animal would get entangled in a fiber optic cable, sonobuoy wires, or guidewire while these were sinking or settling on the seafloor. An animal would have to swim through loops or become twisted within the cable or wire to become entangled, and given the properties of the expended cables and wires (low breaking strength and sinking rates) the likelihood of entanglement from cables and wires is extremely low. Additionally, as noted above, though there are numerous documented cases where marine mammals have been entangled in anthropogenic materials (e.g., fishing gear), there have been no documented instances where a marine mammal has been entangled in military expended cables and wires despite decades of training and testing activities being conducted in the action area and elsewhere utilizing wires and cable. For these reasons, the likelihood that ESA-listed cetaceans become entangled in military expended wires and cables in the action area is so low as to be discountable.

The Navy's vessel entanglement systems use biodegradable polymers which are designed to entangle the propellers of in-water vessels. Biodegradable polymers are broken-down by organisms and enzymes into smaller compounds over time. The rate at which they degrade, as well as the size of the resulting compound varies from hours to years depending on whether the polymers are natural or synthetic (Karlsson and Albertson 1998b). The constituents of this material that the Navy uses is expected to break down into small pieces within a few days to weeks, and will further degrade and dissolve into the water column within weeks to a few months. The final products are all environmentally benign and will quickly be dispersed into undetectable concentrations in the water column. For these reasons, biodegradable polymers only retain their strength for a relatively short period of time and are extremely unlikely to pose a potential entanglement risk to marine mammals. Additionally, due to the wide dispersion and low numbers of biodegradable polymers used by the Navy, coupled with the patchy distribution of ESA-listed marine mammals in the action area where these materials are dispersed, there is a very low likelihood of ESA-listed marine mammals interacting with biodegradable polymers while they are an entanglement risk. In summary, we find that the probability of exposure to effects of entanglement in biodegradable polymers is extremely unlikely and thus discountable for marine mammals.

Decelerators/parachutes also may pose a risk of entanglement, though for the reasons described below, we do not believe such incidences are likely to occur. The Navy uses a variety of sizes of decelerators in the action area (Table 58). The majority of the decelerators/parachutes used are in the small size category and are associated with sonobuoys. Both small- and medium-sized decelerators/parachutes are made of cloth and nylon and have weights attached to their short attachment lines (i.e., from 1 to 19 ft) to speed their sinking. According to the Navy's BA, small and medium parachutes with weights may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the seafloor, where it becomes flattened (Group 2005). Therefore, the majority of parachutes/decelerators would not remain suspended in the water column for more than a few minutes as most have weights that speed the sinking of the materials to the seafloor. Some large and extra large decelerators/parachutes are also proposed for use in the action area. In contrast to small and medium parachutes, large and extra large parachutes do not have weights attached and may remain at the surface or suspended in the water column for some time prior to eventual settlement on the seafloor. However, a limited number of these items are proposed for use each year (i.e., 50 large and 5 extra large) and during some activities (aerial targets launched from shore), efforts are made to recover large and extra large parachutes. The small number of large and extra large parachutes proposed for use annually and the fact that some of these parachutes are recovered reduces the potential for ESA-listed marine mammals to encounter and become entangled in these items.

As noted above, the vast majority of large whale entanglements have been associated with fishing gear, some of which has been actively fishing, and some of which is derelict (NOAA 2014a). For example, between 2010 and 2014, 24 records of North Atlantic right whale mortality or serious injury were documented involving entanglement or fishery interactions. In contrast, as noted previously, there has never been a documented instance where a large whale was observed entangled in military expended material, including decelerators/parachutes. There are a number of key differences between parachutes/decelerators and fishing gear that result in the likelihood of entanglement in parachutes being significantly lower than it is for fishing gear. First, as noted above, most decelerators/parachutes used by the Navy sink quickly to seafloor and do not remain suspended in the water column for extended periods of time. This is in contrast to fishing gear which can be left in the water for days or weeks at a time. Additionally parachutes would be highly visible in the water column likely alerting a nearby animal to the presence of the obstacle in the water column (Figure 49), whereas fishing gear may consist of some buoys and traps that are visible, but also many hundreds of feet of rope in between these items that is not (Figure 50). Finally, the cords associated with parachutes are, at most, 80 ft long. In contrast, typical gear associated with the American lobster fishery (in which large whales are regularly entangled) has hundreds of ft of rope suspended in the water column (Figure 50).

Figure 49. Aerial target with deployed parachute (Navy 2017a).

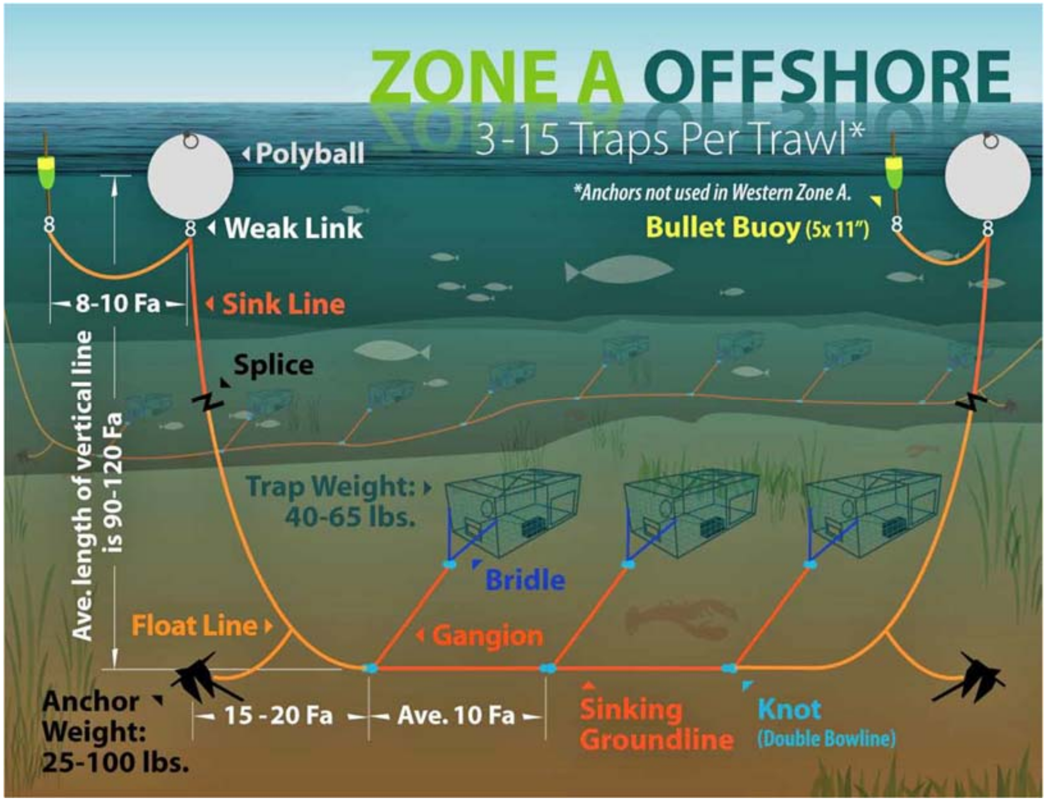


Figure 50. A typical gear configuration for the lobster trap fishery (McCarron and Tetreault 2012).

It is also possible that a bottom feeding animal (e.g., sperm whale) could become entangled when they are foraging in areas where parachutes have settled on the seafloor. For example, if bottom currents are present, the canopy may temporarily billow and pose a greater entanglement threat. However, the likelihood of bottom currents causing a billowing of a parachute, a relatively rare ESA-listed marine mammal encountering this billowing parachute, and the animal not detecting and avoiding the entanglement risk is so unlikely as to be considered discountable. Further, and as noted previously, there has never been a documented instance where a bottom feeding marine mammal was entangled in a Navy parachute.

In conclusion, for the reasons described above, NMFS considers it extremely unlikely for any marine mammals to become entangled in military expended materials. Therefore, potential effects on ESA-listed marine mammals from entanglement in military expended materials are discountable.

9.1.1.6 Ingestion Stressors – Marine Mammals

Additional discussion on ingestion stressors is included in Section 6.6. The munitions and other materials small enough to be ingested by ESA-listed marine mammals are small- and medium-caliber projectiles, broken pieces of firing targets, chaff, flare caps, and shrapnel fragments from explosive ordnance. Other military expended materials (e.g., non-explosive bombs or surface targets) are too large for marine mammals to consume and/or are made of metal a marine mammal would not be able to break-apart to ingest. Most expendable materials will be used over deep water and these items will sink quickly and settle on the seafloor with the exception of chaff and some firing target materials. Given the limited time most items will spend in the water column, it is not likely that these items will be accidentally ingested by ESA-listed marine mammals that do not typically forage on the sea floor.

Watters et al. (2010) conducted a visual survey of the seafloor that included a portion of the Navy's Southern California Range Complex (i.e., an area where similar Navy military readiness activities using military expended materials are concentrated) as part of a 15-year quantitative assessment of marine debris on the seafloor off the California coast. The authors found plastic was the most abundant material and along with recreational monofilament fishing line, dominate in the debris documented on the seafloor (note that U.S. Navy vessels have a zero-plastic trash discharge policy and return all plastic waste to appropriate disposal sites on shore). There was only one item found that was potentially "military" in origin. Keller et al. (2010) characterized the composition and abundance of man-made marine debris during groundfish bottom trawl surveys in 2007 and 2008 along the U.S. west coast at 1,347 randomly selected stations. This including some sample sites that were within the Southern California portion of the action area and within that subset, some that included historically used post-World War II dump sites. The evidence that post-World War II dump sites were sampled was indicated by items recovered that included equipment described as "helmets," "gas masks," "uniforms," and other miscellaneous and diverse items including "plastic," "file cabinets," and "buckets" that are not (since approximately the 1970s) disposed of at sea and are not military expended material associated with the activities in the proposed action. For this reason, the "military debris" discovered by Keller et al. (2010) is not the same as the material expended during proposed training and testing activities during military readiness training and testing activities. Based on this information, military expended material is not expected to be commonly encountered on the seafloor of the action area.

Sperm whales are capable of foraging along the sea floor in deep water. Sperm whales are recorded as having ingested fishing net scraps, rope, wood, and plastic debris such as plastic bags and items from the seafloor (Walker and Coe 1990; Whitehead 2003). However, the relatively low density of both sperm whales and expended materials along the vast sea floor suggests ingestion would be rare. If a sperm whale were to accidentally ingest expended materials small enough to be eaten, it is likely the item will pass through the digestive tract and not result in an injury (e.g., Wells et al. 2008a) or an increased likelihood of injury from significant disruption of normal behavioral patterns such as breeding, feeding, or sheltering.

ESA-listed marine mammals may also encounter military expended material that remains suspended in the water column for extended periods of time. Since baleen whales feed by filtering large amounts of water, they could encounter and consume debris at higher rates than other marine animals (NOAA 2014b). For example, baleen whales are believed to routinely encounter microplastics (from numerous anthropogenic sources) within the marine environment based on concentrations of these items and baleen whale feeding behaviors (Andrady 2011b). In a comprehensive review of documented ingestion of debris by marine mammals by Laist (1997), there are two species of mysticetes (bowhead and minke whale) with records of having ingested debris items that included plastic sheeting and a polythene bag. This effort was followed up by a comparative summary of the earlier review with additional information and the number of mysticete species with documented records of ingestion increased to seven species, including right whales, pygmy right whales, gray whales, and four rorqual species (Bergmann et al. 2015). Information compiled by Williams et al. (2011) listed humpback whale, fin whale, minke whale as three species of mysticetes known to have ingested debris including items the authors characterized as fishing gear, polyethylene bag, plastic sheeting, plastic bags, rope, and general debris. Military expended material has not been documented as having been consumed.

Some Styrofoam, plastic endcaps, and other small military expended materials may float for some time before sinking. However, these items are likely too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it. For example, chaff is composed of fine fibers of silicon dioxide coated with aluminum alloy. Due to their light weight and small size they float and can be carried great distances in both air and water currents. Their dispersal in wind and water results in chaff fibers likely occurring in low densities on the ocean surface. Several literature reviews and controlled experiments have indicated that chaff poses little risk, except at concentrations substantially higher than those that could reasonably occur from military training (Arfsten et al. 2002; Force 1997; Hullar et al. 1999). Given the small size, low densities, and low toxicity of chaff, any accidental ingestion by ESA-listed marine mammals feeding at the ocean surface is not expected to result in an injury or an increased likelihood of injury from significant disruption of normal behavioral patterns such as breeding, feeding, or sheltering. Chaff cartridge plastic end caps and pistons would also be released into the marine environment during Navy activities, where they may persist for long periods and therefore could be ingested by marine mammals while initially floating on the surface and sinking through the water column. However, these end caps would eventually sink to the seafloor where they would be less likely to be ingested by marine mammals. Firing target materials are normally retrieved before sinking so it is not reasonable to expect ingestion of these items to occur.

In conclusion, ingestion of military expended material of sufficient size to cause on adverse effect by ESA-listed marine mammals is extremely unlikely and thus make the effect of this stressor discountable.

9.1.2 Sea Turtles

We determined that several of the acoustic stressors, all of the energy stressors, entanglement stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect ESA-listed green (North Atlantic DPS), hawksbill, Kemp’s ridley, leatherback, and loggerhead (Northwest Atlantic Ocean DPS) sea turtles. As noted above, our analysis for these stressors is organized on the taxa level (i.e., sea turtles) because the pathways for effects for these stressors is generally the same for all sea turtles and we would not expect different effects at the species level. While there is variation among species within each taxa, the sea turtle species considered in this opinion share many similar life history patterns and other factors (e.g., morphology) which make them similarly vulnerable (or not) to the stressors associated with the proposed action. Our analysis for these stressors and sea turtles is summarized below.

9.1.2.1 Acoustic Stressors – Sea Turtles

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. NMFS determined that these acoustic stressors are not likely to adversely affect ESA-listed sea turtles. The effects of additional acoustic stressors, which NMFS determined are likely to adversely affect marine mammals, are discussed in Section 9.2.2.

9.1.2.1.1 Vessel Noise – Sea Turtles

The Navy vessels used during training and testing activities will produce low-frequency, broadband underwater sound below 1 kHz (for larger vessels), and higher-frequency sound between 1 kHz to 50 kHz (for smaller vessels), although the exact level of sound produced varies by vessel type. Therefore ESA-listed turtles could be exposed to a range of vessel noises within their hearing abilities. Depending on the context of exposure, potential responses of North Atlantic DPS green, hawksbill, Kemp's ridley, leatherback, and the Northwest Atlantic DPS of loggerhead sea turtles to vessel noise disturbance, would include startle responses, avoidance, or other behavioral reactions, and physiological stress responses. Very little research exists on sea turtle responses to vessel noise disturbance. Currently, there is nothing in the available literature specifically aimed at studying and quantifying sea turtle response to vessel noise. However, a study examining vessel strike risk to green sea turtles suggested that sea turtles may habituate to vessel sound and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of the specific stressor associated with vessels to which turtles are responding, they only appear to show responses (avoidance behavior) at approximately 10 m or closer (Hazel et al. 2007). Therefore, the noise from vessels is not likely to affect sea turtles from further distances, and disturbance may only occur if a sea turtle hears a vessel nearby or sees it as it approaches. These responses appear limited to non-injurious, minor changes in behavior based on the limited information available on sea turtle response to vessel noise.

For these reasons, vessel noise is expected to cause minimal disturbance to sea turtles. If a sea turtle detects a vessel and avoids it or has a stress response from the noise disturbance, these responses are expected to be temporary and only endure while the vessel transits through the area where the sea turtle encountered it. Therefore, sea turtle responses to vessel noise disturbance are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated), and a sea turtle would be expected to return to normal behaviors and stress levels shortly after the vessel passes by.

9.1.2.1.2 Aircraft Overflight Noise – Sea Turtles

As with vessel disturbance above, little information is available on how ESA-listed sea turtles respond to aircraft. For the purposes of this consultation, we assume all ESA-listed sea turtles

(North Atlantic DPS of green, hawksbill, Kemp's ridley, Northwest Atlantic DPS of loggerhead, and leatherbacks) may exhibit similar short-term behavioral responses such as diving, changes in swimming, etc., which is also consistent with those behaviors observed during aerial research surveys of sea turtles. We are unaware of any data on the physiological responses sea turtles exhibit to aircraft, but we conservatively assume a low-level, short-term stress response is possible.

The working group that developed the 2014 *ANSI Guidelines* for fishes and sea turtles did not consider this specific acoustic stressor for sea turtles in part because it is not considered to pose a great risk (Popper et al. 2014). Although the aircraft used by the Navy can produce extensive airborne noise from either turbofan or turbojet engines, via sonic booms, and from helicopter rotary wing low-frequency sound and vibration, depending on the altitude, some sound would not be transmitted into the water, and any low-flying altitude air craft would only likely transmit low levels of sound within one meter into the water column. As mentioned previously, we assume that sea turtles located at or near the water surface may exhibit startle reactions to certain aircraft overflights if the aircraft is flying at a low altitude and the turtle can see it or detect it through sound or water motion generated from wind currents on the surface. This would most likely occur when helicopters are hovering (other aircraft are mostly flying at higher altitudes) and might be visually detected by a sea turtle. The currents and waves the helicopter produces on the water's surface may also cause sea turtles to respond to the disturbance along with the sound.

The Navy proposes to conduct exercises involving helicopters both during the day and night. These exercises 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 and may hover over the water. Longer duration activities (such as a couple of hours) and periods of time where helicopters hover may increase the chance that a sea turtle may startle, change swimming patterns, or have a physiological stress response. There could also be temporary masking of biologically relevant cues from exercises that generate longer duration of sound exposure with a hovering helicopter. However, in general, aircraft overflight is brief, and does not persist in the action area for significant periods of time (not longer than a few hours), nor is the sound expected to be transmitted well into the water column. Thus, the risk of masking any biologically relevant sound to sea turtles is extremely low. A sea turtle could leave the area where noise disturbance persists for a few hours, and thereby avoid continued disturbance. Any startle reactions that occur, if any, are expected to be brief, with sea turtles resuming normal behaviors once the aircraft is no longer detectable or leaves the area. Due to the short-term nature of any exposures to aircrafts and the brief responses expected to the noise or visual disturbance produced, the effects of aircraft overflight noise on ESA-listed sea turtles is considered temporary and insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.2.1.3 Weapons Noise – Sea Turtles

Individual sea turtles from all of the ESA-listed species (North Atlantic DPS green, hawksbill, Kemp's ridley, the Northwest Atlantic DPS of loggerhead and leatherback) may be exposed to sounds caused by the weapons firing (guns, missile, torpedoes), objects dropping in the water, and inert impact of non-explosive munitions on the water's surface. In general, these are impulsive sounds generated in close proximity to or at the water surface (with the exception of items that are launched underwater). Most in-air weapons noise is expected to be reflected at the air-water interface, and as such is not expected to transmit deep into the water column nor propagate across a large expanse of surface waters. This noise would be limited and strongest underwater just below the surface and directly under the firing point of the weapon. Sound produced from missile and target launches is typically the highest near the initiation of the booster rocket and rapidly fades as the missile or target travels downrange from the firing point (Navy 2017a).

The highest level of sound expected to transmit to the water would be from large-caliber guns fired at the lowest elevation angle with peak levels of sound directly below the blast. These peak levels are approximately 200 dB (re 1 μPa). These levels are lower than the impulsive sound pressure thresholds that could cause hearing impairment or injury to sea turtles, but slightly higher than the rms value (175 dB) that could elicit a behavioral response. Therefore, the potential effects that are more likely to result from weapons noise exposure for sea turtles are temporary behavioral responses, masking and concurrent stress responses.

All of the noise produced during the use of the weapons described here is expected to be brief (few seconds). Most incidents of impulsive sounds produced by weapons firing, launch, or inert object impacts would be single events, with the exception of gunfire activities. Gunfire activities could produce multiple shots fired in a brief period of time. Given that these sounds are below injury criteria for sea turtles, and are expected to be very brief and intermittent over the duration of activities in the action area, only brief startle reactions, diving responses or other avoidance behaviors are likely to occur for sea turtles. For the same reasons, masking of biologically relevant sounds is also not expected to occur for sea turtles because weapons noise will not persist for a long enough duration, and sea turtles are more likely to rely on other senses to detect environmental cues such as visually or through orientation to the earth's magnetic field. Most of these activities will typically occur more than 12 NM from the coast; therefore, sea turtles would still be able to detect biologically relevant sounds near the coastal areas they inhabit or need to detect near nesting beaches.

In addition, as described in the proposed mitigation measures (Section 3.4.2) for the proposed action, the Navy will not commence with weapons firing if *Sargassum* mats are observed, or if a sea turtle is observed within the mitigation zone. These measures will help reduce the likelihood of impacts on hatchling and pre-recruitment juveniles of all sea turtle species and leatherback turtles of all age classes because these species and age classes are known to congregate around *Sargassum*. For these reasons, any physiological stress and behavioral reactions from weapons firing noise would likely be brief and are expected to return to normal shortly after the weapons noise ceases. Therefore, the effects on sea turtles from weapons noise exposure are anticipated to be minor, temporary and will not lead to a significant disruption of normal behavioral patterns.

As such the effects from weapons noise on sea turtles is considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.2.2 Energy Stressors – Sea Turtles

This section analyzes the potential impacts of energy stressors used during training and testing activities within the action area on sea turtles. Additional discussion on energy stressors is included in Section 6.3. This section includes analysis of the potential impacts of: (1) in-water electromagnetic devices and (2) high-energy lasers.

9.1.2.2.1 In-water Electromagnetic Devices – Sea Turtles

The in-water electromagnetic devices that the Navy proposes to use during training and testing activities include towed or unmanned mine warfare systems that mimic the electromagnetic signature of a vessel passing through the water. A full description of these devices is provided in Section 6.3 of this biological opinion. In general, the voltage used to power these devices is approximately 30 volts, with just 35 volts (capped at 55 volts) in saltwater, required to generate a current. These levels are considered safe for marine species due to the low charge relative to salt water. The static magnetic field generated by the mine neutralization devices is of relatively minute strength. Typically, the maximum magnetic field generated would be approximately 2,300 microteslas. For comparison, this level is substantially lower than common everyday items such as refrigerator magnets, which is 15,000 to 20,000 microteslas (Navy 2017a).

Magnetic fields and other cues (e.g., visual cues), are known to be important for sea turtle orientation and navigation (Lohmann et al. 2000; Putman et al. 2015). Sea turtles use geomagnetic fields to navigate at sea, and therefore changes in those fields could impact their movement patterns (Lohmann and Lohmann 1996; Lohmann and Lohmann 1998). Turtles in all life stages orient to the earth’s magnetic field to position themselves in oceanic currents and directional swimming presumably aided by magnetic orientation has been shown to occur in some sea turtles (Christiansen et al. 2016b). This life strategy enables them to locate seasonal feeding and breeding grounds and return to their nesting sites (Lohmann and Lohmann 1996; Lohmann and Lohmann 1998). Sea turtles have been shown able to detect changes in magnetic fields, which may cause them to deviate from their original direction (Lohmann and Lohmann 1996, Lohmann et al. 1997). For example, Liboff (2016) determined that freshly hatched sea turtles are able to detect and use the local geomagnetic field as a reference point before embarking a post-hatchling migration. This study suggests that the information is transferred from the mother to the egg through some undetermined geomagnetic imprinting process.

Sea turtles may also use nonmagnetic cues for navigation and migration, and these additional cues may compensate for variations in magnetic fields. Putman et al. (2015) conducted experiments on loggerhead hatchlings and determined that electromagnetic fields may be more important for sea turtle navigation in areas that may constrain a turtle’s ability to navigate by other means (cold temperatures or displacement from a migration route). The findings of this study suggest that the magnetic orientation behavior of sea turtles is closely associated with ocean ecology and geomagnetic environment (Putman et al. 2015). Other studies on behavioral responses of sea turtles to magnetic fields have been conducted on green and loggerhead sea turtles (Normandeau et al. 2011a). Loggerhead sea turtles have been shown to be sensitive to electromagnetic field intensities ranging from 0.005 to 4,000 microteslas. Green turtles were found to be sensitive to field intensities from 29.3 to 200 microteslas. Although data is lacking for other sea turtle species, the sensitivities of loggerhead and green turtles is assumed similar to other species.

As stated above, the static magnetic fields generated by electromagnetic devices used in training and testing activities are of relatively minute strength. The maximum strength of the magnetic field is approximately 2,300 microteslas, with the strength of the field decreasing further from the device. At a distance of four meters from the source of a 2,300 microtesla magnetic field, the strength of the field is approximately 50 microteslas, which is within the range of the Earth's magnetic field (25 to 65 microteslas). At eight meters, the strength of the field is approximately 40 percent of the Earth's magnetic field, and only 10 percent at 24 m away from a 2,300 microtesla magnetic field (Navy 2017a). Therefore, at a distance of 200 m (the maximum predicted distance of the magnetic field proposed for use by the Navy) the strength of the magnetic field would be approximately 0.2 microteslas (Navy 2017a), which is less than one percent of the strength of the Earth's magnetic field. This is likely within the range of detection for sea turtle species, but at the lower end of their sensitivity to the field.

For any sea turtles located in the immediate area (within about 200 m) where in-water electromagnetic devices are being used, adult, sub-adult, juveniles, and hatchling sea turtles could be temporarily disoriented and could deviate from their original movements, but the extent of this disturbance is likely to be inconsequential given the brief duration of the potential disorientation (seconds or minutes). These brief behavioral disruptions are expected to be limited and minor, and not anticipated to result in any significant effect, beyond what would be similar to natural stressors regularly occurring in the animal's life cycle. Therefore, the effects from exposure to in-water electromagnetic devices for sea turtles is considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.2.2.2 Lasers – Sea Turtles

As discussed above, high-energy laser (lasers) weapons training and testing involves the use of up to 30 kilowatts of directed energy as a weapon against small surface vessels and airborne targets. These weapons systems are deployed from surface ships and helicopters to create small but critical failures in potential targets and used at short ranges from the target (Navy 2017a). These lasers would only be used in open ocean areas of the actions area, and would therefore not affect species located nearshore.

For sea turtles, the primary concern with lasers used during Navy training and testing is the potential for a sea turtle to be struck by a high-energy laser beam. If this were to occur, it would likely be for turtles located at or near the surface, and could result in injury or death, resulting from traumatic burns from the high-energy beam. However, sea turtles could only be exposed to the beam if the laser missed the target, and a sea turtle was located near it. For any turtles located deeper in the water column, the probability of being struck by a laser decreases. In addition, as stated by the Navy, laser platforms are typically on helicopters and ships, which may cause sea turtles to move away from the area for reasons such as ship or aircraft noise, making a strike from the laser beam less likely.

Within the action area, the use of lasers will occur within the Virginia Capes and Jacksonville Range Complexes. However, only four annual training events using high energy lasers are proposed in each of these complexes. Sea turtles species and life stages that could be present in these areas are hatchlings and pre-recruitment juveniles of all sea turtle species, adult loggerhead turtles, and leatherback turtles of all age classes. According to the Navy's probability estimate (Appendix F, Military Expended Material and Direct Strike Analysis in the Phase III AFTT DEIS/OEIS), a direct laser strike on a sea turtle during training activities would be extremely rare. The Navy assumed: 1) all sea turtles would be at or near the surface 100 percent of the time, and would not account for the duration of time a sea turtle would be diving; and 2) that sea turtles are stationary, which does not account for any movement or any potential avoidance of the training or testing activity in response to other stressors that would likely occur in the wild. Based upon sea turtle densities, loggerhead turtles have the highest seasonal density within the areas where high-energy lasers will be used. Therefore, these density numbers for loggerhead were used to estimate the potential of a laser strike for all sea turtles that could be present. The Navy's modeling results show that 0.000008 loggerhead turtles would be exposed to a high-energy laser strike. Based on this extremely low probability of occurrence, coupled with the other assumptions described above, NMFS considers it extremely unlikely for any sea turtles to be struck by a high-energy laser. Therefore, potential effects on sea turtles from lasers are considered discountable.

9.1.2.3 Physical Disturbance and Strike Stressors – Sea Turtles

Additional discussion on physical disturbance and strike stressors is included in Section 6.4. This Section analyzes the potential impacts of the various types of physical disturbance, including the potential for strike, during training and testing activities within the action area from military expended materials, including non-explosive practice munitions and fragments from high-explosive munition, and seafloor devices. Vessel strike of sea turtles is discussed in section 9.2.2.4.

9.1.2.3.1 Military Expended Materials – Sea Turtles

Navy activities involving military expended materials occur both nearshore and offshore along the Atlantic coast, but the majority of materials would be expended in offshore areas. During

Navy activities that produce military expended materials, the potential for a strike of ESA-listed sea turtles exists from all sizes of non-explosive practice munitions, fragments from high-explosive munitions, expendable targets, and expended materials other than munitions; such as sonobuoys, expended bathythermographs, and torpedo accessories. Current Navy gunnery exercises, include firing a variety of weapons and using a variety of non-explosive training and testing rounds, including 5 inch naval gun shells, and small-, medium-, and large-caliber projectiles. The larger-caliber projectiles are only used in the open ocean beyond 20 NM. The chance of a turtle being hit is related to the sea turtle life history and likelihood of presence in the action area when materials are expended. The primary concern with these materials is for a sea turtle located at or near the water surface to be struck. If this occurs, a turtle could be harmed. The chances of this occurring depend on several factors discussed below.

For areas located nearshore (including estuarine waters), the highest concentration of military materials would be expended near the James River and tributaries in Virginia, as well as the Lower Chesapeake Bay and Port Canaveral, Florida. Hatchlings of all sea turtle species could be present very briefly along coastal areas, nearshore as they leave the nest, enter the water, and move to offshore areas. Hatchlings located as far north as Virginia would most likely be green, Kemp's ridley, and loggerhead sea turtles, because these are the only species that nest that far north. Hatchlings of leatherback turtles may be located as far north as North Carolina, as this is the northernmost extent of leatherback nesting areas in the action area. Juvenile, sub-adult, and adult loggerhead, green, Kemp's ridley, and hawksbill turtles are most likely to be present in nearshore areas within benthic foraging grounds. Sub-adult and adult leatherbacks that forage at the surface in coastal and estuarine waters could also be present. Hawksbill turtles are unlikely to occur near Florida, as they rarely nest in areas there that overlap with Navy activities (USFWS 2013).

For training activities occurring in the offshore waters, the species and age classes most likely to be impacted are hatchlings and pre-recruitment juveniles of all sea turtle species, adult loggerhead turtles, and leatherback turtles of all age classes. Adult sea turtles in these areas could be located at the surface of the water, but generally spend most of their time submerged. Thus, adult sea turtles are expected to be at the surface for brief periods of time compared to hatchlings and juveniles, as these early life stages spend more time at the surface while in ocean currents. However, all life stages do spend some time at the surface basking. Because the Navy will not commence activities that expend materials (e.g. weapons firing) near concentrated *Sargassum* mats, the chances of these life stages being affected is low. Moreover, sea turtles are expected to be widely distributed in offshore waters, decreasing the chances of a single or repeated exposure to sea turtles since these offshore areas do not have sea turtle presence year-round.

While no strike from military expended materials has ever been reported or recorded for sea turtles, the possibility of a strike exists, although it is unlikely. For this reason, the Navy conservatively estimated the probability of a direct strike to a sea turtle based upon the distribution and density estimates they have for the species and the number of activities that would pose a risk occurring throughout the action area. In order to estimate potential direct strike exposures, the Navy developed a scenario using the sea turtle species with the highest average monthly density in areas that occur where there are the greatest amounts of military expended material. Within the action area, this is within the Virginia Capes and Jacksonville Range Complexes. Input values to the Navy model include munitions data (frequency, footprint and type), size of the training or testing area, sea turtle density data and size of the animal (Navy 2017a). The Navy also totaled the highest combined amounts of military expended materials annually in a complex within the action area. Since loggerhead sea turtles have the highest seasonal densities, they are used as a proxy for modeling impacts to all sea turtle species that could be present during Navy activities. The Navy analysis also assumes the following:

- The model is two-dimensional and assumes that all sea turtles would be at or near the surface 100 percent of the time and does not consider any time a sea turtle would be submerged.
- The model does not take into account the fact that most of the projectiles fired during training and testing activities are fired at targets, and most projectiles hit those targets, so only a very small number of those would hit the water at a maximum velocity and force.
- The model assumes the animal is stationary and does not account for any movement of the sea turtle or any potential avoidance of the training or testing activity.

The Navy's model estimates that within the Virginia Capes Range Complex, approximately 0.08 direct strike exposures per year could occur during training activities, and 0.03 during testing activities. In the Jacksonville Range Complex, the model estimates 0.06 direct strikes during testing activities and 0.03 direct strike exposures per year for training activities. As stated previously, for the purposes of modeling, only Virginia Capes and Jacksonville Range Complexes were used because these two training areas would have the highest estimated numbers and concentrations of military expended materials for activities under the Navy's proposed action, and would provide a reasonable comparison and worst case scenario for all other areas with fewer expended materials. Based on a worst-case scenario, the Navy's model results indicate with a reasonable degree of certainty that sea turtles would not be struck by non-explosive practice munitions, expendable targets, and expended materials during training activities. NMFS agrees with these results and expects for a sea turtle to be struck only if a projectile (and fragments) failed to hit the target, which has a low probability of occurring. Projectiles that do not miss would have most of their impact energy absorbed by the target. Furthermore, all non-explosive torpedoes, as well as target-related materials that are intact after the activity are recovered, which reduces the risk of a sea turtle being hit by sinking objects. Any fragments and sinking objects that are not recovered generally sink through the water slowly and can be avoided by most sea turtles of any life stage.

Based upon the risk of a sea turtle being hit by military expended materials, the probability of a sea turtle being directly hit is extremely low. The more likely response would be a brief behavioral disturbance for sea turtles located at the surface that move away from the activity. These brief disturbances are not expected to result in any long-term consequence to an individual sea turtle, such as growth, survival, or overall fitness. Therefore, potential impacts on sea turtles are anticipated to be insignificant (i.e., so minor that the effect cannot be meaningfully evaluated) from military expended materials.

9.1.2.3.2 Seafloor Devices – Sea Turtles

Offshore activities that use seafloor devices would primarily occur in the Virginia Capes Range Complex, and other locations such as Navy Cherry Point, Jacksonville, Key West, and Gulf of Mexico Range Complexes; and the Naval Surface Warfare Center, Panama City Testing Range. Some training activities could be conducted within inshore waters including and surrounding Boston, Massachusetts; Narragansett, Rhode Island; Earle, New Jersey; Delaware Bay, Delaware; Wilmington, Delaware; Hampton Roads, Virginia, the Lower Chesapeake Bay; James River and tributaries; York River; Morehead City, North Carolina; Cooper River, South Carolina; Savannah, Georgia; Kings Bay, Georgia; Mayport, Florida; Port Canaveral, Florida; Tampa Florida; Beaumont, Texas; and Corpus Christi, Texas.

For activities that occur in offshore waters, the species and age classes that may be impacted are juvenile, sub-adult, and adult loggerhead, green, and hawksbill turtles, especially if seafloor devices are placed in waters where the depths are within benthic foraging ability dive depths. The loggerhead sea turtle is the most abundant species in the Virginia Capes Range Complex, and adults may be found foraging in waters as deep as 200 m (Hochscheid 2014; Rieth et al. 2011). Juvenile sea turtles, such as green turtles may also rest and forage in waters as deep as 30 m (Hochscheid 2014; Rieth et al. 2011), and hawksbill turtles have been recorded at dive depths of 80 m. Juvenile and adult leatherback turtles are more likely to co-occur where seafloor devices are used in offshore areas given their preference for open-ocean habitats and feeding throughout the water column, and may dive to depths greater than 1,000 m. All sea turtle species are expected to be greatly dispersed throughout offshore waters of the action area.

For nearshore activities, juvenile, sub-adult, and adult leatherback and loggerhead sea turtles, as well as green, Kemp's ridley, and hawksbill sea turtles that are located in benthic foraging habitats are most likely to be affected by seafloor devices since this is where the devices are used. However, based upon the Navy model that estimated number of sea turtles present when military materials are expended (previously described), which also takes into account the use of seafloor devices, the probability (less than 1/10) of an individual sea turtle being struck by a seafloor device is also extremely low. Furthermore, the likelihood of a sea turtle encountering and being disturbed by seafloor devices in benthic foraging habitats is unlikely because these items are either stationary or move very slowly along the bottom making them easily avoidable by a sea turtle. Thus, sea turtles would be expected to ignore or avoid any slowly moving or stationary device, making the effects of seafloor devices on sea turtles insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.2.4 Entanglement Stressors – Sea Turtles

All of the ESA-listed sea turtles present within the action area could encounter materials that have the potential to entangle them such as wires and cables, decelerators and parachutes, and biodegradable polymers that are used during Navy activities. Sea turtles could encounter these items at the water's surface, in the water column, or along the seafloor. Many factors may influence the degree of entanglement risk for sea turtles such as and life stage and size, sensory capabilities, and foraging methods (i.e. along the seafloor or in the water column). Similar to other marine animals, most entanglements associated with sea turtles are from fishing gear (as opposed to military items) that float or are suspended at the ocean's surface for long periods of time.

9.1.2.4.1 Cables and Wires

Fiber optic cables, as discussed previously, can range in size up to 3,000 m in length. It is the longer cables that pose a greater risk of entanglement, as well as how long the line remains in the water. Both of these factors may increase the chance of a sea turtle encountering these materials. However, because fiber optic cables are not expected to remain suspended in the water for long periods, and are expected to sink rapidly, the likelihood of a turtle at the surface or in the water column encountering them is low. Additionally, the material from these cables is very brittle, making it easily broken if bent or twisted, which also decreases the likelihood that a turtle would become ensnared. Furthermore, because most of the Navy activities that use fiber optic cables occur in deep waters, most cables would ultimately settle upon deep ocean substrates beyond the diving depth range for the sea turtle species and life stages considered here. Because fiber optic cables are brittle and easily broken, will not persist in the waster column for long durations, and would ultimately settle in very deep waters, the likelihood of a turtle encountering them is extremely low.

Similar to fiber optic cables, guidance wires may pose an entanglement threat to sea turtles either in the water column or after the wire has settled to the seafloor. However, the likelihood of a sea turtle encountering and becoming entangled in a guidance wire is low, as the sink rate to the seafloor (at an estimated rate of 0.7 ft per second) is fast, and the probability of a sea turtle encountering a wire as it descends is lower than encountering it after it has settled. Also similar to fiber optic cables, the guide wires have a relatively low tensile breaking strength; between 10 and 42 pounds (Navy 2017a) and are more likely to break, further reducing entanglement risk for sea turtles. These wires may also degrade after settling along the substrate. The Navy estimates they would break down within one to two years and therefore no longer pose an entanglement risk after that time.

Sonobuoy wires, consist of a thin-gauge, hard draw copper strand wire, wrapped by a hollow rubber tubing or bungee. The tensile breaking strength of the sonobuoy wire and rubber tubing is no more than 40 pounds. Operationally, sonobuoys remain suspended in the water column for no more than 30 hours, after which they sink to the seafloor, which would increase the likelihood that a sea turtle could encounter a sonobuoy wire either while it is suspended or as it sinks (Navy 2017a). However, as with fiber optic wires, sonobuoys are weak and likely to break if wrapped around a sea turtle. Bathythermographs wires are similar to sonobuoys, and expected to have the same fate, as such are expected to pose little risk for sea turtles.

Any ESA-listed sea turtles that occur within the action area could at some time encounter expended cables or wires. Based upon the numbers and geographic locations of where the Navy will use these materials, they pose a higher risk of entanglement for sea turtles located at the water's surface or in the water column rather than those foraging along the seafloor. Because of this, hatchlings and pre-recruitment juveniles of all sea turtle species, and leatherback turtles of all age classes are more likely to encounter these materials in offshore areas. Because of their size, adult sea turtles have a higher risk of entanglement than smaller turtles such as hatchlings and juveniles since larger turtles are considered less able to disentangle from loops that may form in lines. However, since this material has different tensile strength and breaks easier than the fishing gear (which is a commonly documented cause of sea turtle entanglement), the risk of a larger seas turtle remaining entangled in wires or cables is low.

In shallower waters, nearshore, these wires and cables may pose a slight risk to juvenile, sub-adult, and adult loggerhead, green, hawksbill, and Kemp's ridley who forage along the substrate. But for the reasons described above, most cables from sonobuoys would be expended in waters too deep for benthic foraging, so bottom foraging sea turtles would not interact with them once they sink, thereby decreasing any risk of entanglement for these species and life stages. Moreover, the sink rates of cables and wires would minimize the potential for these items to drift into nearshore and coastal areas from offshore, where these species and life stages are more likely to occur in benthic foraging areas.

Given the low concentration of expended wires and cables, the rapid sink rates, the tensile strength and breakability of the material, and likely distribution of sea turtles in the action area that may co-occur with areas where cables and wires are expended, NMFS considers it extremely unlikely for any sea turtles to be exposed to entanglement in cables and wires as part of the proposed action. For these reasons, the potential impacts from these stressors on sea turtles are discountable.

9.1.2.4.2 Decelerators and Parachutes

The type of decelerators and parachutes used by the Navy during training and testing activities range in size from 18 inches up to 80 ft in diameter. The majority being proposed for use are small (18 inches), cruciform shaped, and are used with sonobuoys. Illumination flares use medium parachutes, up to 19 ft in diameter. The small decelerators and parachutes have attachment cords up to 3 ft in length, and the medium decelerators and parachutes have attachment cords up to 18 ft in length. Some aerial targets use large and extra-large decelerators and parachutes up to 50 ft and 80 ft in diameter, respectively. The majority of these larger sized chutes that the Navy would expend are the large parachutes, with a small amount of extra-large ones as well. These large and extra-large chutes have long attachment cords, up to 70 ft and 82 ft in length, respectively. Some of the decelerators and parachutes associated with shore-launched aerial targets will be recovered, when possible.

Based upon the number or activities that will use decelerators and parachutes, and the geographic distribution of these activities that would co-occur with sea turtles, green, leatherback, loggerhead and Kemp's ridley sea turtles are the most at risk of entanglement during Navy training activities, and not during testing. Therefore, we focused our assessment primarily on the Navy's training activities that will use decelerator and parachute assemblies and may affect these species. Given the location of where most of the decelerators and parachutes would be expended in conjunction with hawksbill sea turtle distribution, hawksbill sea turtles are unlikely to be impacted by parachutes and decelerators. The sea turtle species that have a higher change of encountering parachutes and decelerators are the North Atlantic DPS of green, Kemp's Ridley, leatherback, and Northwest Atlantic DPS of loggerhead sea turtles. These species may encounter expended decelerators and parachutes from training activities in the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville, Gulf of Mexico, and Key West Range Complexes, as well as other portions of the action area (Navy 2017a).

Juvenile, sub-adult, and adult green turtles are expected to be present only north of North Carolina during warmer months between May through October. Juvenile green turtles are observed annually in the waters off Virginia and in the Chesapeake Bay, but are unevenly distributed throughout these waters (Barco and Lockhart 2015). Virginia's coastal and estuarine waters are important seasonal developmental (foraging) habitats for juvenile Kemp's ridley turtles (Keinath et al. 1987; Lutcavage and Musick 1985; Mansfield 2006). Individual juvenile Kemp's ridley turtles have been known to return to the same seasonal foraging areas, such as the Chesapeake Bay, for many years (Lutcavage and Musick 1985; Mansfield 2006). The northern Gulf of Mexico including the western coast of Florida and the upper Texas coast appear to also be developmental habitat for Kemp's ridley turtles (USFWS 2015; Weber 2009).

The leatherback sea turtle is more likely to occur in offshore waters where these Navy activities take place due to their preference for open-ocean habitats and their feeding behavior. Leatherback sea turtles have been observed annually in the waters off Virginia and the Chesapeake Bay, mainly from May through October (Barco and Lockhart 2015). There is the potential for a leatherback sea turtle to encounter an expended decelerator and parachute assembly while feeding at the surface or in the water column, but the potential is less probable at the seafloor given the preference of this species to forage near the surface.

The loggerhead sea turtle is the most abundant species in the Virginia Capes and Jacksonville Range Complexes. Juvenile, sub-adult, and adult loggerhead turtles are found north of North

Carolina during warmer months of May through October (Barco et al. 2016b; Barco and Lockhart 2015). As with Kemp's ridley sea turtles, Virginia's coastal and estuarine waters are important foraging habitats for juvenile loggerhead sea turtles (Keinath et al. 1987; Lutcavage and Musick 1985; Mansfield 2006). Individual juvenile loggerhead sea turtles are known to return to the same seasonal foraging areas, such as the Chesapeake Bay for many years (Lutcavage and Musick 1985; Mansfield 2006).

Based on the numbers and geographic locations of their use, decelerators and parachutes have the potential to pose a risk of entanglement for all age classes of any ESA-listed sea turtle species. However, the Navy has noted there are no known instances of sea turtle entanglement with a decelerator and parachute assembly.

Sea turtles at or near the water's surface are more likely to encounter and become entangled by floating decelerators, parachutes and cords than those animals located deeper in the water column or foraging along the seafloor. Sea turtles have the potential to become entangled by these materials, especially if the parachute lands directly on the sea turtle, or if the sea turtle encounters and swims into the chutes and cords before they sink.

The small and medium decelerators and parachutes are not expected to remain at the water's surface for long, and would begin to sink within five to 15 seconds. Once these smaller chutes reach the substrate, they will likely flatten and not "billow" from the bottom. The large and extra-large chutes may remain at the surface of the water for up to five minutes before eventually sinking to the seafloor. While a decelerator and parachute is sinking, it could be carried along within a current, or become snagged on a hard structure near the substrate.

Any decelerators or parachutes that do settle have some small degree of risk to become resuspended, however it is more likely that these items would become buried in sediments as ocean currents move sediment around along the seafloor, or organisms colonize them. It is also possible for some of the material to degrade over time, this would be influenced by ultraviolet radiation, the extent of physical damage the decelerator and parachute assembly sustains at the surface, as well as water temperature and ultimate sinking depths. Benthic-feeding turtles tend to forage in nearshore and coastal areas more so than offshore, where most of the decelerators and parachutes will be expended. Although the sink rates of small and medium decelerator and parachute assemblies would rule out the possibility of these drifting great distances into nearshore and coastal areas where benthic foraging species of sea turtles are more likely to occur. The small and medium chutes would sink in offshore waters too deep for benthic foraging (beyond dive depths), so bottom foraging sea turtles would not interact with these materials once they sink. Given the sparse distribution of the small and medium decelerators and parachutes deployed and expended throughout the action area, as well as the patchy distribution and general behavior of sea turtles, the potential for impacts from entanglement with small and medium decelerators and parachutes is extremely low. Thus, sea turtles are not likely to encounter small and medium decelerators and parachutes once they sink and settle along the substrate.

The likelihood for entanglement is higher for the large and extra-large chutes due to their size and length of the attachment cords, and because some of the large and extra-large decelerators and parachutes have the potential to be expended nearshore, which have a higher concentration of sea turtles. Additionally, these sized parachutes and decelerators are not weighted with anything to help them sink rapidly, thus could potentially remain suspended in the water column for an extended period of time, increasing the chance of sea turtles encountering them in the water column. However, significantly fewer large and extra-large decelerators and parachutes are expended annually during Navy activities, and therefore the chance for a sea turtle to encounter them is extremely low given sea turtle distributions throughout these areas.

While in the water column, a sea turtle is not likely to become entangled in these materials because the parachute would have to land directly on the turtle, or the turtle would have to swim into the parachute and its lines, before it sank. Should this unlikely event occur, a sea turtle could likely free itself and swim away from the sinking chute. If the parachute and associated lines sink to the seafloor in an area that is calm along the substrate, it would likely settle there and remain undisturbed. In an area with bottom currents or active tidal influence, the parachute may move along the seafloor, away from the location in which it was expended. But over time, it may become covered by sediment in most areas or colonized by attaching and encrusting organisms, which would further stabilize the material and reduce the potential for reintroduction as an entanglement risk. Bottom-feeding sea turtles tend to forage in nearshore areas rather than offshore, where these parachutes are used. Therefore, green, hawksbill, Kemp’s ridley, and loggerhead sea turtles are not likely to encounter parachutes once they reach the seafloor. The potential for a leatherback sea turtle to encounter an expended parachute while feeding at the surface or in the water column is still extremely low, given the sink rate of the parachute, and is even less probable at the seafloor, given the general behavior of the species to feed near the surface. For these reasons, the risk of entanglement of sea turtles by parachutes and decelerators is extremely low and therefore discountable for all ESA-listed sea turtles.

9.1.2.4.3 Biodegradable polymers

As previously described in this opinion, the Navy’s vessel entanglement systems use biodegradable polymers which are designed to entangle the propellers of in-water vessels. Biodegradable polymers are broken-down by organisms and enzymes into smaller compounds over time. The rate at which they degrade, as well as the size of the resulting compound varies from hours to years depending on whether the polymers are natural or synthetic (Karlsson and Albertson 1998a). The constituents of this material that the Navy uses is expected to break down into small pieces within a few days to weeks, and will further degrade and dissolve into the water column within weeks to a few months. The final products are all environmentally benign and will quickly be dispersed into undetectable concentrations in the water column. For these reasons, biodegradable polymers only retain their strength for a relatively short period of time and are extremely unlikely to pose a potential entanglement risk to sea turtles. Entanglement risk for adults and larger size juveniles is unlikely, but hatchlings have the potential to encounter this material before it completely loses tensile strength and therefore risks to hatchlings could last for days to weeks, or the time it takes for these compounds to degrade and lose tensile strength or become too small for a hatchling to become entangled. However, due to the wide dispersion and low numbers of biodegradable polymers used by the Navy, coupled with the patchy distribution of sea turtles in the action are where these materials are dispersed, there is a very low likelihood of hatchlings interacting with biodegradable polymers while they are an entanglement risk. In summary, we find that the probability of exposure to effects of entanglement in in biodegradable polymers is extremely unlikely and thus discountable for sea turtles.

9.1.2.5 Ingestion Stressors – Sea Turtles

The munitions and other materials NMFS considers small enough to be ingested by ESA-listed sea turtles are small and medium caliber projectiles (up to 2.25 in), broken pieces of firing targets, chaff, flare casings (caps and pistons), decelerators and parachutes (cloth, nylon and metal weights) and shrapnel fragments from high-explosives ordnance. Most expendable materials will be used over deep water and these items will sink quickly and settle on the seafloor with the exception of chaff and some firing target materials.

Navy training activities involving non-explosive practice munitions in the inshore waters occur in several locations along the Atlantic coast, but fewer munitions are anticipated to be expended on an annual basis in these inshore areas compared to activities located in offshore areas. Therefore, most of the expended munitions would occur in deeper waters. The highest concentration of munitions in in-shore waters would be in the James River and Tributaries. Other in-shore locations include the Lower Chesapeake Bay, Port Canaveral, Florida, and Narragansett Bay, Rhode Island. In inshore waters, training activities would concentrate small-caliber shell casings in areas that may potentially be over benthic foraging areas (e.g., Lower Chesapeake Bay and Port Canaveral). Lifestages of sea turtles potentially affected in these areas would be juvenile, sub-adult, and adult green, loggerhead, Kemp's ridley, and hawksbill sea turtles. These species are more likely to encounter munitions of ingestible size that settle on the substrate. Because leatherback sub-adult and adult sea turtles forage in coastal surface waters, they would be less likely to ingest expended materials.

Types of munitions that can result in fragments include demolition charges, projectiles, missiles, and bombs. The size of these fragments would vary in size, depend on the net explosive weight, size, and munitions type. However, the metal materials are expected to quickly sink and settle on the seafloor. Fragments that could be encountered by sea turtles would most likely be those that have settled on the seafloor. Other munitions and munitions fragments such as large-caliber projectiles or intact training and testing bombs are too large for sea turtles to consume and are made of metal a sea turtle would not be able to break apart and ingest. Chaff fibers are too small for sea turtles to confuse with prey and forage, but there is the possibility that sea turtles could come in contact or accidentally ingest some of the material. If this occurs, chaff is not expected to impact sea turtles due to the low concentration that would be ingested and the small size of the fibers. Chaff is composed of fine fibers of silicon dioxide coated with aluminum alloy. Due to their light weight and small size they float and can be carried great distances in both air and water currents. Their dispersal in wind and water results in chaff fibers likely occurring in low densities on the ocean surface. Given the small size, low densities, and low toxicity of chaff, any accidental ingestion by ESA-listed sea turtles feeding at the ocean surface is not expected to result in an injury or an increased likelihood of injury from significant disruption of normal behavioral patterns such as breeding, feeding, or sheltering. Firing target materials are normally retrieved before sinking so it is not reasonable to expect ingestion of these items to occur.

Chaff cartridge plastic end caps and pistons would also be released into the marine environment, during Navy activities, where they may persist for long periods and therefore could be ingested by sea turtles while initially floating on the surface and sinking through the water column. However, these end caps would eventually sink to the seafloor where they would be less likely to be ingested by some life stages or species of sea turtles, such as hatchlings and pre-recruitment juveniles of all sea turtle species and all life stages age of leatherback sea turtles. As mentioned above, green, hawksbill, Kemp's ridley, and loggerhead sea turtles could have a higher potential to ingest these items if they settle in potential benthic feeding habitat.

Should a sea turtle encounter military expended materials, it is unlikely that it would ingest every fragment it encounters. Sea turtles may attempt to ingest a projectile and then reject it after realizing it is not a food item. Additionally, ingestion of items would not necessarily result in injury or mortality to the individual if the item does not become embedded in tissue (e.g., Wells et al. 2008a). It is likely that most ingested material would pass through the digestive tract of the animal. NMFS is unaware of any data indicating military items have been found in sea turtles that have been necropsied, unlike plastics that appear similar to jellyfish or other prey to a sea turtle (Schuyler et al. 2016). Plastic bags are the most commonly ingested type of debris amongst sea turtles (NOAA 2014b). If material is ingested, ingestible-sized items would likely be spit out or passed through the digestive tract without significantly impacting the individual. In addition, given the limited geographic area where materials other than munitions are expended during a given event, and the short duration of time these military expended materials would remain in the water column, the probability of a sea turtle encountering these materials is low.

In conclusion, ingestion of military expended material of sufficient size to cause on adverse effect by ESA-listed sea turtles is extremely unlikely and thus make the effect of this stressor discountable.

9.1.3 **Fishes**

We determined that several of the acoustic stressors, all of the energy stressors, entanglement stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect ESA-listed Gulf of Maine DPS Atlantic salmon, Atlantic sturgeon (all DPSs), giant manta ray, Gulf sturgeon, oceanic whitetip shark, Central and Southwest Atlantic DPS scalloped hammerhead shark, and smalltooth sawfish. As noted above, our analysis for these stressors is organized on the taxa level (i.e., fishes) because the pathways for effects for these stressors is generally similar for all fishes and we would not expect different effects at the species level. While there is variation among species within each taxa, the fish species considered in this opinion share many similar life history patterns and other factors (e.g., morphology) which make them similarly vulnerable (or not) to the stressors associated with the proposed action. Where species-specific information is relevant, this information is provided in this section. Our analysis for these stressors and fishes is summarized below.

9.1.3.1 Acoustic Stressors – Fishes

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. NMFS determined that these acoustic stressors are not likely to adversely affect ESA-listed fishes. The effects of pile driving and explosives, other acoustic stressors which NMFS determined were likely to adversely affect ESA-listed fishes, are discussed in Section 9.2.3.1 and Section 9.2.3.2, respectively.

9.1.3.1.1 Vessel Noise – Fishes

The Navy vessel movements considered here involve transits to and from ports to various locations within the action area. As described above, Navy training and testing activities involve intermittent vessel movements ranging in duration from a few hours to a few weeks, although this movement is widely dispersed throughout the action area. The only exception to this is for pierside activities, located inshore in areas which are already heavily disturbed from anthropogenic noise due to regular, ongoing vessel traffic (e.g., waterfront users, recreational and commercial fisheries, ports, marinas). Navy vessels make up a very small percentage of the overall traffic (0.7 percent), a maximum of one percent in most areas (Mintz 2012b), although they do contribute to the overall amount of background and ambient noise levels.

Individuals of all ESA-listed fish species considered in this biological opinion may be exposed to sound from vessel movement during Navy training and testing activities. In general, information regarding the effects of vessel noise on fish hearing and behaviors is limited. Some TTS has been observed in fishes exposed to elevated background noise and other white noise, a continuous sound source similar to noise produced from vessels. Caged studies on sound pressure sensitive fishes show some TTS after several days or weeks of exposure to increased background sounds, although the hearing loss appeared to recover (e.g., Scholik and Yan 2002; Smith et al. 2006; Smith et al. 2004b). Smith et al. (2004b) and Smith et al. (2006) exposed goldfish (a fish with hearing specializations, unlike any of the ESA-listed species considered in this opinion) to noise with a sound pressure level of 170 dB re 1 μPa and found a clear relationship between the amount of TTS and duration of exposure, until maximum hearing loss occurred at about 24 hours of exposure. A short duration (e.g., 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. 2004b). Recovery times were not measured by researchers for shorter exposure durations, so recovery time for lower levels of TTS was not documented.

Vessel noise may also affect fish behavior by causing them to startle, swim away from an occupied area, change swimming direction and speed, or alter schooling behavior (Engas et al. 1998; Engas et al. 1995; Mitson and Knudsen 2003). Physiological responses have also been documented for fish exposed to increased boat noise. Nichols et al. (2015b) demonstrated physiological effects of increased noise (playback of boat noise) on coastal giant kelpfish. The fish exhibited acute stress responses when exposed to intermittent noise, but not to continuous noise. These results indicate variability in the acoustic environment may be more important than the period of noise exposure for inducing stress in fishes. However, other studies have also shown exposure to continuous or chronic vessel noise may elicit stress responses indicated by increased cortisol levels (Scholik and Yan 2001; Wysocki et al. 2006). These experiments demonstrate physiological and behavioral responses to various boat noises that have the potential to affect species' fitness and survival, but may also be influenced by the context and duration of exposure. It is important to note that most of these exposures were continuous, not intermittent, and the fish were unable to avoid the sound source for the duration of the experiment because this was a controlled study. In contrast, wild fish are not hindered from movement away from an irritating sound source, if detected, so are less likely to subjected to accumulation periods that lead to the onset of hearing damage as indicated in these studies. In other cases, fish may eventually become habituated to the changes in their soundscape and adjust to the ambient and background noises.

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Navy vessels produce moderate to low-level passive sound sources (larger Navy ships would produce low-frequency, broadband underwater sound below 1 kHz; and smaller vessels emit higher-frequency sound between 1 kHz to 50 kHz). Therefore, ESA-listed fishes could be exposed to a range of vessel noises, depending on the source and context of the exposure. Because of the characteristics of vessel noise, sound produced from Navy vessels is unlikely to result in direct injury, hearing impairment, or other trauma to fishes. Plus, in the near field, fish are able to detect water motion as well as visually locate an oncoming vessel. In these cases, most fishes located in close proximity that detect the vessel either visually, via sound and motion in the water would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance away. These reactions may include physiological stress responses, or avoidance behaviors. Auditory masking due to vessel noise can potentially mask vocalizations and other biologically important sounds that fish may rely on. However, impacts from Navy vessel noise would be intermittent, temporary and localized, and such responses would not be expected to compromise the general health or condition of individual fish from continuous exposures. Instead, the only impacts expected from exposure to Navy vessel noise for fishes may include temporary auditory masking, physiological stress, or minor changes in behavior.

Therefore, similar to marine mammals and sea turtles, exposure to vessel noise for fishes could result in short-term behavioral or physiological responses (e.g., avoidance, stress). Vessel noise would only result in brief periods of exposure for fishes and would not be expected to accumulate to the levels that would lead to any injury, hearing impairment or long-term masking of biologically relevant cues. For these reasons, exposure to vessel noise is not expected to significantly disrupt normal behavior patterns of fishes in the action area. Therefore, the effects of vessel noise on ESA-listed fishes is considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.3.1.2 Aircraft Overflight Noise – Fishes

All ESA-listed fish species considered in this biological opinion (Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, oceanic whitetip sharks, the Central and Southwest DPS of scalloped hammerhead shark, shortnose sturgeon, and smalltooth sawfish) could be exposed to aircraft-generated overflight noise throughout the action area. The only species that will not encounter aircraft noise is the Nassau grouper. Nassau grouper are typically found along the seafloor and near reef systems where aircraft sound will result in no impacts.

As described previously, most of the sounds produced by aircraft used during Navy activities would be concentrated around airbases and fixed ranges within each of the Naval range complexes. In addition, should any sound transmit into the water column, it would likely only be to a shallow depth and would be below the range of any injury criteria for fishes. Furthermore, aircraft quickly pass overhead, with helicopters potentially hovering for a few minutes or up to a few hours over the water's surface. As described above, sound transmission into deep depths of the water column is not likely, and sound that is transferred into the water from air is only within a narrow cone under the aircraft. Therefore, only fishes located at or near the surface of the water and within the limited area where transmission of aircraft noise is expected to occur have the potential to detect any noise produced from low-flying aircraft.

Direct injury and hearing impairment in fishes is extremely unlikely to occur from aircraft overflight noise, because sounds from aircraft noise, including occasional sonic booms, lack the amplitude or duration to cause any physical damage to fishes underwater. Furthermore, due to the brief and dispersed nature of aircraft overflights, masking of biologically relevant sounds for fishes is also extremely unlikely. In the rare circumstance a fish detects sound produced from an aircraft overhead, only very brief startle or avoidance responses would be expected. Additionally, due to the short-term, transient nature of aircraft noise, ESA-listed fishes are unlikely to be exposed multiple times within a short period of time that could lead to ongoing behavioral disruptions or stress. Any physiological stress and behavioral reactions would likely be short-term (seconds or minutes) and are expected to return to normal shortly after the aircraft disturbance ceases. Therefore, the effects on fishes from aircraft overflight noise are anticipated to be minor, temporary and will not lead to a significant disruption of normal behavioral patterns. As such the effects from aircraft overflight noise on fishes is considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.3.1.3 Weapons Noise – Fishes

Of the ESA-listed fishes likely to be present during the firing of weapons during Navy training and testing activities, Atlantic salmon, Atlantic sturgeon, giant manta rays, Gulf sturgeon, oceanic whitetip sharks, and Central and Southwest DPS of scalloped hammerhead sharks, could all be exposed to noise from weapons firing, launch, flight downrange, and from the impact of non-explosive munitions. Nassau grouper, shortnose sturgeon and smalltooth sawfish are not expected to encounter weapons noise. Nassau grouper are typically located along the seafloor and near reef systems outside the range of these activities. Shortnose sturgeon will not encounter weapons noise due to a lack in habitat overlap (i.e., they are largely confined to rivers and estuaries) within the action area where Navy activities will not occur. In addition, smalltooth sawfish are typically found in nearshore, shallow waters (less than 1 m) around the tip of Florida where no weapons noise is expected. Although a few adults could be located in deep water reefs around Florida, they are not expected to encounter weapons noise since the majority of the sound would occur at the water's surface.

For the other fish species mentioned, weapons noise could affect fishes located at the surface of the water, albeit in a narrow footprint under a weapons trajectory, as described previously. In addition, any objects that are dropped and impact the water with great force could produce a loud broadband sound at the water's surface from large-caliber non-explosive projectiles, non-explosive bombs, and intact missiles and targets (Mclennan 1997).

Naval gunfire could also elicit a brief behavioral reaction such as startle reactions or avoidance and could expose fishes to multiple shots within a few seconds. The sound produced from missile and target launches is typically at a maximum during initiation of the booster rocket, but rapidly fades as the missile or target travels downrange; therefore this noise is unlikely to affect fishes underwater. These are launched from aircraft which would produce minimal sound in the water due to the altitude of the aircraft when these are fired.

For exposed fishes, most of the weapons noise produced from these activities lack sound characteristics such as duration and high intensity that would accumulate or cause mortality, injury, or hearing impairment. The average peak levels of 200 dB are also below the peak levels for impulsive sound sources that could lead to onset of injury for fishes. Additionally, because these activities are brief in duration and widely dispersed throughout the action area, accumulation of levels high enough to cause TTS or masking of biologically relevant sound for fishes is also extremely unlikely. As with the other stressors for fishes discussed in this section, exposure to the sound produced from weapons would only be expected to cause brief behavioral or stress responses should they detect the noise. Fish may react by exhibiting startle responses, rapid bursts in movement, changes in swimming direction or orientation, or leaving the immediate area of the sound. Concurrent with these behavioral responses, fishes could also experience temporary increases in heart rate or stress hormones. However, any behavioral reactions and physiological stress would likely be brief, and are expected to return to normal shortly after the weapons noise ceases. Therefore, the effects on fishes from weapons noise are anticipated to be minor, temporary, and are not expected to lead to a significant disruption of normal behavioral patterns. As such, the effects from weapons noise on fishes is considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.3.1.4 Sonar and Transducers – Fishes

General categories and characteristics of Navy sonar systems proposed for use during activities considered in this biological opinion are described in Section 6.1.3. The Navy anticipates only a few activities involving sonar and other transducers will occur in inshore waters (within bays and estuaries), including at pierside locations. All ESA-listed fishes have the potential to be exposed to sonar and other transducers during Navy activities included in this biological opinion. However, direct injury from sonar and other transducers is considered extremely unlikely. These types of sound sources are considered to pose less risk to fish species because the sound produced from sonar characteristically has lower peak pressures and slower rise times than other acoustic stressors that are known to injure fish such as impulsive sounds from pile driving, or the strong shock waves produced from detonation of explosives. Direct injury from sound levels produced from the type of sonar the Navy uses has not been documented in fishes (Halvorsen et al. 2012e; Kane et al. 2010; Popper et al. 2014; Popper et al. 2007; Popper et al. 2013). However, there is the potential for some hearing impairment from sonar, as well as behavioral and stress responses, which are discussed below.

As described previously, fishes are not equally sensitive to noise at all frequencies. Some species of fishes have specialized adaptations which increases their ability to detect sounds at higher frequencies. However, none of the ESA-listed fishes that may be affected by Navy activities possess any hearing specializations. For these reasons, grouping fish according to the presence of a swim bladder and whether or not that swim bladder is involved in hearing and their known hearing frequency ranges (audiograms) is considered the best approach for the purposes of our analyses (described in Section 2.3). All of the ESA-listed fish species that have a swim bladder considered in this opinion do not have a swim bladder associated with hearing, thus the sound criteria used for fishes are based upon fishes with swim bladders not involved in hearing (Atlantic salmon, Atlantic sturgeon, Gulf sturgeon, shortnose sturgeon, and Nassau grouper) and fishes that do not possess a swim bladder (Oceanic whitetip shark, Giant manta ray, scalloped hammerhead sharks, and smalltooth sawfish).

Exposure to Surveillance Towed Array Sensor System (SURTASS) Low-Frequency Active sonar has been tested at maximum received levels of 193 dB re 1 μPa (218 dB Sec_{om}) and has not been shown to cause mortality or any injury in fish with swim bladders (Kane et al. 2010; Popper et al. 2007). The researchers exposed three freshwater species of fish, the rainbow trout (*Oncorhynchus mykiss*), channel catfish (*Ictalurus punctatus*), and the hybrid sunfish (*Lepomis sp*.), to both low- and mid-frequency sonar. Low-frequency sonar exposures with received sound pressure levels of 193 dB re 1 μPa occurred for either 324 or 648 seconds. This study exposed the fish to low-frequency sonar pulses for time intervals that would be substantially longer than what would occur in nature (e.g., unconfined fishes), but the fish did not experience mortalities or damage to body tissues at the gross or histological level. Hearing was measured both immediately post-exposure and for several days thereafter. Catfish and some specimens of rainbow trout showed 10 to 20 dB of hearing loss immediately after exposure to the low-frequency active sonar when compared to baseline and control fish; however, another group of rainbow trout showed no hearing loss. Recovery in trout took at least 48 hours, but studies on recovery were not completed. The reason for the different results between rainbow trout groups is not known. But the researchers speculated it may be due to developmental 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. Furthermore, examination of the inner ears of the fish during necropsy revealed no differences from the control groups in ciliary bundles or other inner ear features indicative of hearing loss (Kane et al. 2010). Lesser potential for injurious effects would be expected for fish without swim bladders, because the presence of a swim bladder increases risk of injury as the sound wave passes through a fish's body and causes the swim bladder to resonate with the sound frequency.

No studies have indicated any physiological damage to adult fish from mid-frequency sonar. However, studies on juvenile herring survival following intense sonar exposures affected less than 0.3 percent of the total juvenile stock (Kvadsheim and Sevaldsen 2005). Similarly, Jorgensen et al. (2005) exposed larvae and juvenile fishes of Atlantic herring (*Clupea harengus*) Atlantic cod (*Gadus morhua*), saithe (*Pollachius virens*), and spotted wolffish (*Anarhichas minor*) to sounds that were designed to simulate mid-frequency sonar transmissions (1 to 6.5 kHz) to study the effects of the exposure on the survival, development, and behavior. The fish were placed in plastic bags three meters from the sound source and exposed to between four and 100 pulses of one-second duration of pure tones at 1.5, 4, and 6.5 kHz. The fish in only two groups out of the 42 tested exhibited adverse effects beyond a behavioral response. These two groups were both composed of herring (a fish with hearing specializations), and were tested with sound pressure levels of 189 dB re 1 μPa, which resulted in a post-exposure mortality of 20 to 30 percent. In the remaining 40 tests, there were no observed effects on behavior, growth (length and weight), or the survival of fish that were kept as long as 34 days post exposure. While statistically significant losses were documented in the two groups impacted, the researchers only tested that particular sound level once, so it is not known if this increased mortality was due to the level of the test signal or to other unknown factors. It is also important to note, that none of the ESA-listed fish species considered in this biological opinion have the hearing specializations similar to herring, as such are not considered as sensitive to sound exposures and associated hearing damage as herring.

In another experiment, Halvorsen et al. (2012e) exposed rainbow trout to simulated mid-frequency sonar (2.8 to 3.8 kHz) sonar at received sound pressure levels of 210 dB re 1 uPa, resulting in cumulative sound exposure levels of 220 dB re 1 uPa. The researches did not observe any mortality or hearing sensitivity changes in rainbow trout and suggested that the frequency range of mid-frequency sonar may be above the most sensitive hearing range of the species.

Some studies have suggested that there may be some loss of sensory hair cells due to high intensity sources. However, none of these studies concurrently investigated effects on hearing. Enger (1981) found loss of ciliary bundles of the sensory cells in the inner ears of Atlantic cod following 1 to 5 hours of exposure to pure tone sounds between 50 and 400 Hz with a sound pressure level of 180 dB re 1 μPa. Similarly, Hastings (1995) found auditory hair-cell damage in a species with notable anatomical hearing specializations, the goldfish (*Carassius auratus*) exposed to 250 Hz and 500 Hz continuous tones with maximum peak levels of 204 dB re 1 μPa and 197 dB re 1 μPa, respectively. Compared to Navy sonar exposures these were long duration exposures of about 2 hours in laboratory settings, much longer than any exposure a fish would normally encounter in the wild during the Navy's proposed activities. The fish exposed in the lab were held in a cage for the duration of the exposure, unable to avoid the source.

Hastings et al. (1996) also demonstrated damage to some sensory hair cells in oscars (*Astronotus ocellatus*) following a 1-hour exposure to a pure tone at 300 Hz with a peak pressure level of 180 dB re 1 μPa. Although in none of the studies was the hair cell loss more than a relatively small percent (less than a maximum of 15 percent) of the total sensory hair cells in the hearing organs.

Hastings (1990b) and Hastings (1995) also demonstrated 'acoustic stunning' (loss of consciousness) in blue gouramis (*Trichogaster trichopterus*) following an 8-minute exposure to a 150 Hz pure tone with a peak sound pressure level of 198 dB re 1 μPa. However, 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. The researchers also found that goldfish exposed to two hours of continuous wave sound at 250 Hz with peak pressures of 204 dB re 1 μPa, and fathead minnows exposed to 0.5 hours of 150 Hz continuous wave sound at a peak level of 198 dB re 1 μPa did not survive. The only study on the effect of exposure of the lateral line system to continuous sound was conducted on a freshwater species, and suggests no effect on these sensory cells by intense pure tone signals (Hastings et al. 1996).

The research described above, and the most recent literature review and summary completed by Popper et al. (2014) regarding fish response to low-frequency and mid-frequency sonar indicate that those species tested to date can be used as viable surrogates for estimating injury in other species exposed to similar sources, and therefore did not provide evidence that injury or mortality could occur from the sonar used by the Navy. 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. Exposures would need to be of a much longer duration than those that typically occur with the Navy's proposed activities. Moreover, if injury or mortality occurs, it is thought to begin at higher sound levels than have been tested to date. In addition, the relative risk of injury or mortality to fish with no swim bladders exposed to low and mid-frequency sonar is lower than fish with swim bladders, no matter the distance from the source.

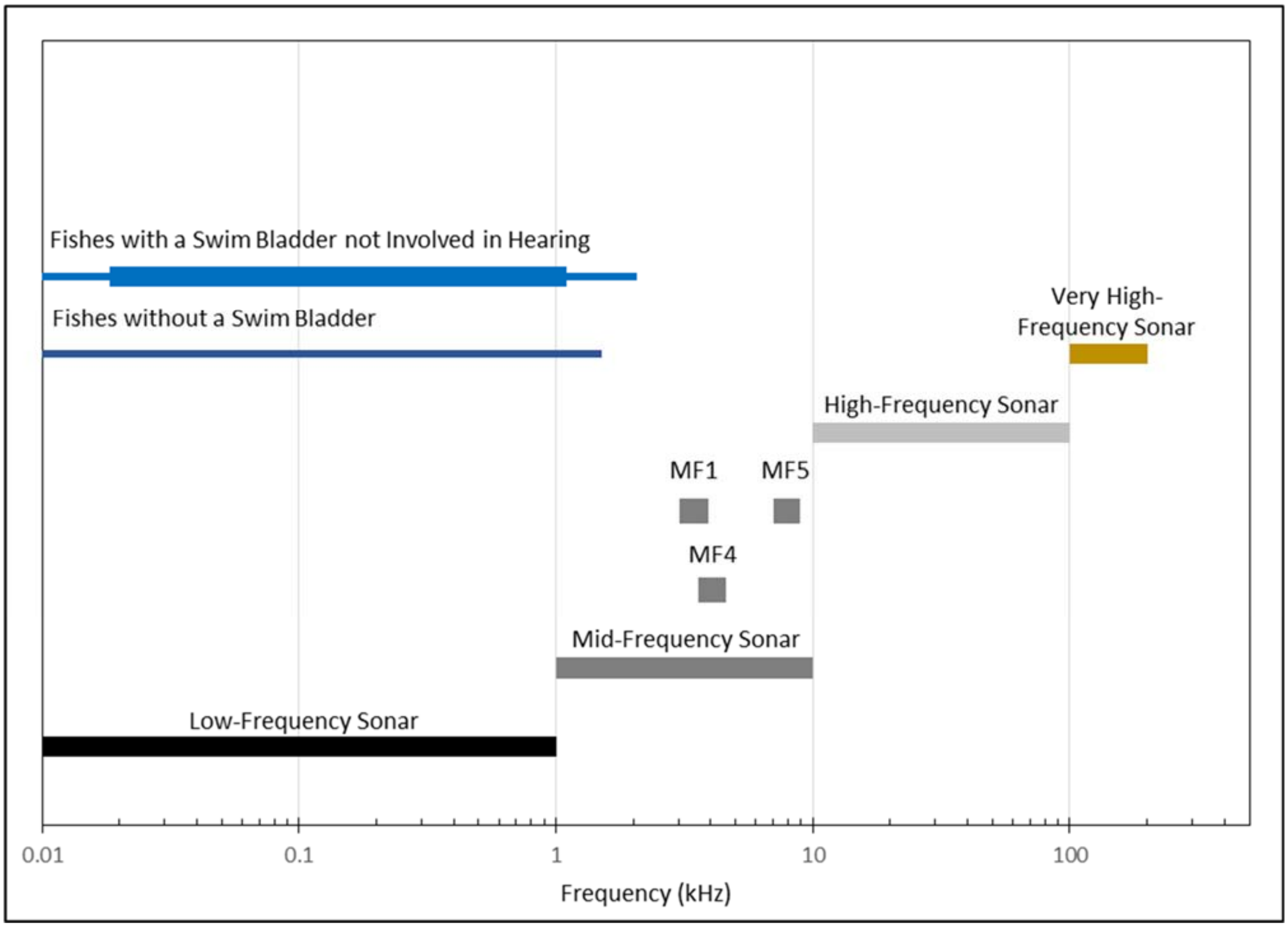
For these reasons, the recommended criteria and thresholds in the 2014 *ANSI Guidelines* are used to predict potential impact to fishes from sonar and transducers (described in Section 2.3). Since it is common practice for hearing thresholds to be based upon SEL_{cum}, to account for the duration of the exposure, the Navy converted the recommended levels to SEL based on the signal duration reported in the original research cited in the 2014 *ANSI Guidelines*, and described above. For low-frequency sonar, only fishes with a swim bladder are likely to develop TTS from low-frequency sonar exposure. Therefore, the recommended threshold for onset of TTS in this fish hearing group would be low-frequency sonars exposure levels greater than 210 dB SEL_{cum} (re 1 μPa^2-s). 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 2 kHz (Halvorsen et al. 2012e; 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. Fishes without a swim bladder (elasmobranchs) are even less susceptible to noise exposure, therefore TTS is also unlikely to occur, and no criteria are proposed. These criteria are provided below in Table 66.

Table 66. 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

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.

Because of the sheer number and diversity of fishes, only a limited amount have had hearing capabilities tested. Figure 51 below, provides a summary of hearing threshold data from available literature (e.g., Casper and Mann 2006; Deng et al. 2013; Mann et al. 2001; Navy 2017a) to demonstrate the potential overall range of frequency detection for each hearing group. However, these estimated hearing ranges may be overly conservative in that they may extend beyond actual species hearing capabilities for a particular group. The upper bounds of each fish hearing group frequency range are 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 from sources with relatively high source levels. Figure 51 is not intended as a composite audiogram, but rather displays the basic overlap in potential detectable frequencies for each fish hearing group associated with the Navy's defined sonar classes (i.e., low-, mid-, high- and very high-frequency) as discussed in Section 6.1 and above.



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 both groups. 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 51. Fish hearing groups and Navy sonar frequency ranges (Navy 2017a).

Based upon the fish hearing and frequency overlap, the ESA-listed fishes considered in this biological opinion would be able to detect most of the Navy sonars within the low-frequency sonar ranges, and would have limited ability to detect mid-frequency sonar. For example, both fish groups (with and without swim bladders) would not be able to detect mid-frequency sonar sources within bins MF1, MF4 and MF5. Also, it is anticipated that most ESA-listed fishes would not be able to hear Navy sonars or other transducers with operating frequencies greater than about 1 to 2 kHz. None of the ESA-listed fish species considered in this opinion can detect high- and very high-frequency sonars and other transducers. Therefore, these species will not be affected by these Navy sonar sources. As described above, mortality or injury from exposure to sonar is highly unlikely for the fish species potentially present in areas where the Navy will use sonar or other transducers. Thus, the most probable effects would be TTS, masking, physiological stress and behavioral responses. However, as stated above, if TTS occurred, it would likely only occur for fishes with swim bladders. No elasmobranchs are expected to sustain TTS from sonar exposure.

In order to estimate the range to effects for fish exposed to sonar, the Navy calculated the range to effects based upon their NAEMO and the respective hearing criteria. Although ranges to effect are predicted, the density data for fish species within the action area are not available, therefore estimates of the total number of fishes that could be affected by sonar and other transducers was not possible. Sonar exposure durations of 1, 30, 60 and 120 seconds were used in the calculations. Due to the relatively low source levels from this sonar source level and duration of sonar exposures, a range of zero meters was predicted for TTS. Therefore, it is unlikely that any fishes with a swim bladder not involved in hearing would experience TTS or any injury from exposure to Navy activities using sonar and other transducers.

Fishes that are able to detect low-frequency sonar and perhaps some mid-frequency sonar, could experience brief periods of masking, or exhibit brief behavioral reactions and stress responses. Fish located closer to the sonar sound source would likely experience more significant responses, whereas fish located further away from the source are less likely to react to the sound levels. However, because the Navy's sonar is moving, and fish are also capable of moving away from the disturbance, the overall exposure duration is expected to be brief and if masking did occur, it would not occur for a significant amount of time and not prevent fish from detecting biologically relevant cues at meaningful levels. Additionally, any physiological stress responses or behavioral reactions would also be expected to be temporary, lasting only a few seconds or minutes during sonar pings. For these reasons, no long-term consequences for ESA-listed fishes are expected. The effects described above are not anticipated to lead to a significant disruption of normal behavior patterns such as breeding, feeding or sheltering, and as such are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated) for Atlantic salmon, Atlantic sturgeon, Gulf Sturgeon, shortnose sturgeon, Nassau grouper, Giant manta ray, Oceanic whitetip shark, scalloped hammerhead shark, and smalltooth sawfish.

9.1.3.1.5 Air Guns – Fishes

Air guns would only be using during testing activities and would be fired 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. Therefore, ESA-listed species of Atlantic salmon, Atlantic sturgeon, giant manta ray, Gulf sturgeon, oceanic whitetip sharks, shortnose sturgeon, and smalltooth sawfish could be exposed to sounds from air guns during Navy testing activities. Nassau grouper and the Central and Southwest Atlantic DPSs of scalloped hammerhead shark are not expected to be present in the areas where air guns will be used. Therefore, these species are not expected to be affected by air gun sound exposure.

Although air guns produce broadband sounds, the pulse duration of an individual signal is approximately 1/10th of a second, and generally lacks the rapid rise time of impact pile driving, or the strong shock wave produced during an explosion. A thorough description of impulsive sound sources and their effects is provided later in Section 9.2.3.1.1 for pile driving.

Using the sound pressure criteria for impulsive sound sources described in Section 2.3. 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. Given the evidence discussed above, air guns have the potential to cause direct lethal and non-lethal injury to small juvenile or larval fish located nearby the source, or induce some type of auditory impairment for adult fishes. Thus, as a conservative measure, range to effects are calculated assuming a maximum of 100 shots. Table 74 presents the approximate ranges in meters to mortality, onset of injury and TTS for air guns for 100 pulses. Although ranges to effects are predicted, density data for fish species within the action area are not available. Therefore, it is not possible to estimate the total number of ESA-listed fishes that may be affected by sound produced by air guns within the respective zones. We will make a qualitative assessment on the potential effects to ESA-listed species from air gun exposures based upon the distance to reach respective thresholds in the water column that correlate to auditory and non-auditory impairment or injury and consider this within the context of air gun exposure location and duration. The distance to these thresholds per fish group is presented below in Table 74.

Table 67. Range to effect for fishes exposed to 100 air gun shots (Navy 2017a).

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 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)

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.
Note: 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, < indicates that the given effect would occur below the reported range(s).

Based upon the distances provided in Table 74, mortality or injury could occur in fishes with a swim bladder (Atlantic salmon, Atlantic sturgeon, Gulf sturgeon) on average at a distance of less than nine meters away from the air gun sound source (within a maximum of 30 m). These effects would occur for elasmobranchs (oceanic whitetip sharks, scalloped hammerhead sharks, giant manta rays, smalltooth sawfish) out to an average distance of less than five meters (maximum of 13 m). Hearing impairment (TTS) if it occurs, may occur in fishes with a swim bladder within a distance of less than 14 m on average (a maximum of 190 m). As stated above, TTS is not known to occur for elasmobranchs, and therefore is not anticipated from exposure to air guns.

In addition to the ranges presented above, the Navy also estimated ranges to effects based upon the *2008 Interim Pile Driving Criteria* described previously (Section 2.3.1) for consideration in the analysis. Based on the criteria, fishes exposed to a peak sound pressure level of 206 dB re 1 μPa may show signs of injury within an average of 10 m from the source (maximum of 23 m). Fishes exposed to a SEL_{cum} of 187 dB re 1 μPa^2-s may show signs of injury or hearing impairment within an average distance of 13 m from the source (maximum ranges 170 m). If fishes less than two grams are present in the vicinity of air gun activities, it is estimated that injury or hearing impairment could occur within an average of 21 m from the source (maximum of 675 m).

As described in Section 2.3, NMFS uses 150 dB rms (dB re 1 μPa) for impulsive sound sources to estimate potential zones where fish may exhibit some degree of a behavioral response. Although this is considered an "informal" criterion, it provides a means of qualitatively assessing potential non-injurious (e.g., sub-injury) response of fishes exposed to impulsive sounds. Based upon the information provided from the Navy for a maximum of 100 air gun shots, the distance to reach the 150dB rms is calculated to be 1,778 m from the air gun pulses.

Although injury and mortality is possible for fishes from air gun exposure, most of the research to date regarding effects from this sound source indicates that injury or mortality are more likely to occur for small, juvenile or larval fish, and temporary hearing impairment could occur for larger fish if they are exposed for a sufficient duration that would lead to onset of TTS. Furthermore, for all fish species and life stages, the probability of any of these effects occurring decreases with increasing distance from the air gun. Since the range to any of these effects is a relatively short distance, the likelihood of any injury or hearing impairment occurring is low. Even though the range to potential behavioral responses is greater than the range for the more serious effects, the likelihood of any significant behavioral responses is also low because the duration of exposure to this sound source is extremely brief. Below we discuss the potential exposure and response of each fish species considered in this opinion to air guns.

Atlantic salmon

For Atlantic salmon, exposure to air guns would only occur in the Northeast Range Complexes and in Newport, RI during spawning adults' seasonal migrations in the spring and summer. However, based on the low annual number of activities to occur in this portion of the action area, and only during the spring months (not summer) while Atlantic salmon could be present, the air gun exposure is expected to be infrequent. No fry or juvenile Atlantic salmon weighing fewer than two grams will be present during air gun use. Therefore, since injury or mortality is more likely to occur for small juvenile fish, these effects are not anticipated for Atlantic salmon. For adult salmon that are present, TTS or behavioral responses are more probable. However, given that these activities occur in offshore areas and are transient, they would only expose individual or schools of salmon in passing. Because of this, it would be unlikely for an Atlantic salmon to accumulate enough sound energy that would lead to the onset of TTS. An Atlantic salmon may be able to detect the sound produced during an air gun pulse and may display a behavioral response indicating it hears the sounds. However, if any behavioral response occurs, it would likely only last for the duration of the sound exposure and not cause a change in behavior that would preclude a salmon from carrying out important life functions. For these reasons only a very low number, if any, of Atlantic salmon would be expected to be located within any of the distances presented above, and would be expected to exhibit brief behavioral responses and not incur any injury of hearing impairment. Any shift in behavior or associated stress response would not last for a duration sufficient to result in long-term deleterious effects on an individual. For these reasons, even if a very few fish are disturbed by the use of air guns and exhibit short behavioral responses, there would be no significant effect on an individual leading to a fitness consequence thus the effects for Atlantic salmon from air gun exposures are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Atlantic Sturgeon

Atlantic sturgeon from each of the five DPSs could be exposed to air gun noise. These exposures would likely occur for fish located in the Northeast and Virginia Capes Range Complexes, and in Newport, Rhode Island (with a few annual exposures occurring pierside). Only sub-adult and adult life stages would be expected to encounter air gun sound in offshore areas. No juvenile sturgeon life stages are expected to occur in these areas, and therefore would not be exposed to air guns sound. As with salmon, air gun activities in offshore areas are transient and may expose sturgeon only in passing. Therefore, a fish would have to be in very close proximity to the source to be injured, and it would also have to be exposed for a longer duration than the brief air gun pulses proposed, to accumulate enough sound that would lead to hearing injury. In addition, a sturgeon would have to be located higher in the water column than is typical for this species, within the area air guns are being used. As with Atlantic salmon, it is more likely Atlantic sturgeon would respond to the sound through either a startle response or some other behavioral response. Any shift in behavior or associated physiological stress response would not be expected to alter normal behavioral patterns (such as migration or feeding) patterns or have some other long-term deleterious effect on an individual. For these reasons, even if a very few Atlantic sturgeon are disturbed by the use of air guns and exhibit short behavioral responses, there would be no significant effect on an individual leading to a fitness consequence, and there would be no significant effect on populations for Atlantic salmon from air gun exposures. Thus the effects for Atlantic sturgeon from air gun exposures are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Gulf Sturgeon

Gulf sturgeon could be exposed to air gun sound in offshore areas in the Gulf of Mexico Range Complex. Only sub adult and adult life stages are expected to be present in offshore areas, where air gun activity would occur. Because air gun activities within these areas are transient, they may expose Gulf sturgeon only in passing. For the same reasons provided above for Atlantic sturgeon, injury from air gun exposure is unlikely and any changes in behavior are not expected to last long enough to have a fitness consequence. Therefore, the effects from air gun exposure on Gulf sturgeon are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Smalltooth Sawfish

It is highly unlikely that smalltooth sawfish will be exposed to air guns due to their low numbers throughout the action area. Although adult smalltooth sawfish that occur in the offshore areas within the Gulf of Mexico Range Complex could be exposed to testing activities that involve the use of air guns, they would have to be located within very short distances, on average less than 5 m (up to 13 m) to sustain any hearing impairment or other injury. Similar to other fish species discussed above, the most likely response of a smalltooth sawfish would be for a temporary behavioral disruption and potential short-duration stress response if it detects the sound produced by an air gun. Because these changes in behavior are considered brief and temporary, and expected to return to normal once the exposure passes, the effects from air guns on smalltooth sawfish are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Giant Manta Ray

Giant manta rays may be exposed to sound from air guns associated with testing activities throughout the action area. Because elasmobranchs are considered less susceptible to injury from impulsive sound sources compared to fish with swim bladders, the likelihood that a giant manta ray would be close enough to air guns sustain injury as described above is extremely low. Only very minor and temporary behavioral changes and associated stress responses would be expected within the larger behavioral (e.g. sub-injury) zone. However, if a giant manta ray detects this sound and is disturbed by it, the disturbance is expected to be brief. As such, the effects from air gun exposure on giant manta rays are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Oceanic Whitetip Shark

Oceanic whitetip sharks may be exposed to sound from air guns associated with testing activities throughout the action area. Because this species spend much of their time at the surface, the risk of exposure to air gun noise could be slightly higher than for species located deeper in the water column. However similar to giant manta rays, oceanic whitetip sharks, would have to be located within very close proximity to the sound source to sustain injury. If anything, they would likely only exhibit minor behavioral changes. Moreover, since this species is relatively rare in the action area, the chances of being exposed to air guns is low for oceanic whitetip sharks. Therefore, NMFS considers the effects on oceanic whitetip sharks from air gun sound to be insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.3.2 Energy Stressors – Fishes

This section analyzes the potential impacts of energy stressors used during training and testing activities within the action area on ESA-listed fish species. Additional discussion on energy stressors is included in Section 6.3. This section includes analysis of the potential impacts of: (1) in-water electromagnetic devices and (2) high-energy lasers.

9.1.3.2.1 In-Water Electromagnetic Devices – Fishes

Navy training activities involving in-water electromagnetic devices that have the potential to affect ESA-listed fishes occur 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. The ESA-listed Atlantic salmon, Nassau grouper, and the Central and Southwest Atlantic DPS of the scalloped hammerhead shark, are not expected to be present within any of these areas and thus would not be exposed to in-water electromagnetic devices. Species that do occur within the areas listed above, include smalltooth sawfish, Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, oceanic whitetip shark and giant manta ray. These species could be exposed to in-water electromagnetic devices with the following exceptions. Juvenile life stages of sturgeon occur in freshwater or estuarine habitats outside of the action area, and therefore these animals are not expected to be affected by electromagnetic devices. Similarly, smalltooth sawfish neonates and juveniles typically inhabit nearshore mangrove habitats, beyond the areas where in-water electromagnetic devices are used during Navy activities and are also not expected to be affected.

A synthesis of information provided by Normandeau et al. (2011a) provides a comprehensive review of information regarding the sensitivity of marine organisms to electric and magnetic impulses. Available data suggests that while many fish species (particularly elasmobranchs) are sensitive to electromagnetic fields (Hore 2012), more research is necessary to understand the physiological response and magnitude of the potential impacts from these sources on fishes.

Many fish groups (including elasmobranchs, sturgeon, and salmonids) have been demonstrated to have an acute sensitivity to electrical fields, known as electroreception (Bullock et al. 1983; Helfman et al. 2009). Fishes are thought to use the same sensory organs used for near field water motion and sound pressure (e.g., lateral line system) for electroreception. In general fish possess two types of electroreceptor organs (Helfman et al. 2009). First, these are ampullary receptors within the skin, which are connected to the surface by a canal filled with a conductive gel that is sensitive to electric fields of low-frequency (< 0.1 to 25 Hz). Second, are tuberous receptors, embedded in the epidermis, and are covered with loosely packed epithelial cells; these receptors detect higher frequency electric fields (50 Hz to > 2 kHz). These receptors are typically found in fishes that use electric organs to produce their own electric fields (e.g. eels). In addition, the distribution of electroreceptors on the head of these fishes, especially around the mouth, such as the rostrum of sawfishes, suggests that these sensory organs may be used in foraging and perhaps social communication (Collin and Whitehead 2004).

Each ESA-listed fish potentially exposed to this stressor has some level of electroreception capabilities. Elasmobranchs (including scalloped hammerheads, oceanic whitetip sharks, giant manta rays, and smalltooth sawfishes) are well known to be sensitive to electromagnetic fields compared to other fish species. Some species have small pores near the nostrils, and around the head and on the underside of the rostrum, called ampullae of Lorenzini, which detect the electromagnetic signature of their prey. Electroreceptors are also 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). These species are known to respond physiologically to electric fields of 10 nanovolts per centimeter and behaviorally at five nanovolts per centimeter (Collin and Whitehead 2004). Kajiura and Holland (2002) demonstrated juvenile scalloped hammerhead sharks were able to detect and respond to electric fields of less than one nanovolt per centimeter. Other studies suggest that sharks are attracted to electromagnetic sources when conditions in the water hinder their other senses such as sight and hearing, so their ability to detect electromagnetic sources helps sharks find prey when in low sensory conditions (Fields 2007).

For teleost fishes (e.g. bony fishes such as salmon and sturgeon), effects of electromagnetic fields could potentially affect orientation in the water column (Fisher and Slater 2010). Electromagnetic sensitivities of many sturgeon species such as Gulf, Atlantic, and shortnose sturgeon have not been heavily studied; however, the presence of electro receptive ampullae in all sturgeon strongly supports the assertion that they are sensitive to electromagnetic energy (Bouyoucos et al. 2014). In addition, electromagnetic sensitivity in some marine fishes is known to be well-developed at early life stages (Ohman et al. 2007), although most of the available research data on electromagnetic sensitivity focuses on adults. A 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. Ohman et al. (2007) also indicate some species appear to be attracted to undersea cables, while others show avoidance, likely due to the electromagnetic fields.

Many species of fish use the Earth's magnetic field for navigation, as is documented for salmon, which use this, as well as the odor of their natal stream, to migrate back to their original spawning grounds (Groot and Margolis 1998; Quinn and Groot 1983). 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). Some species of salmon, tuna, eels and stargazers have been shown to respond to magnetic fields and may also contain magnetite in their tissues (Helfman et al. 2009). Crystals of magnetite have been found in four species of Pacific salmon (Mann et al. 1988; Walker et al. 1988), which are believed to serve as a compass that orients to the Earth's magnetic field. Putnam et al. (2013) provided empirical evidence that salmon use cues from the magnetic field to navigate in the open ocean. Quinn and Brannon (1982) conclude that while salmon can apparently detect B-fields (e.g. magnetic field), their behavior is likely governed by multiple stimuli as demonstrated by the ineffectiveness of artificial B-field stimuli. Supporting this, Yano et al. (1997) found no observable effect on the horizontal and vertical movements of adult chum salmon that had been fitted with a tag that generated an artificial B-field around the head of each fish. Furthermore, research conducted by Ueda et al. (1998) on adult sockeye salmon suggests that, rather than magnetoreception, this species relies on visual cues to locate natal stream and on olfactory cues to reach its natal spawning channel. Blockage of magnetic sense had no effect on the ability of the fish to locate their natal stream.

In a controlled laboratory study, the scalloped hammerhead *(Sphyrna lewini*) and sandbar sharks (*Carcharhinus plumbeus*) exhibited altered swimming and feeding behaviors in response to very weak electric fields (less than 1 nanovolt per cm; Kajiura and Holland 2002). Five Pacific sharks were shown to react to magnetic field strengths of 2,500 to 234,000 microteslas at distances ranging between 0.26 and 0.58 m and avoid the area (Rigg et al. 2009). Similarly, southern stingrays (*Dasyatis americana*) and nurse sharks (*Ginglymostoma cirratum*) have been demonstrated to detect and avoid a fixed magnetic field producing a flux of 95,000 microteslas (O'connell et al. 2010). White sharks (*Carcharodon carcharias*) have also been shown to alter behavior when approaching a towed prey item with an active electromagnetic field (Huveneers et al. 2013). For comparison, the researchers also exposed sharks to static prey items and no behavioral alterations were observed, indicating the sharks were able to detect the electromagnetic field of the towed prey.

Potential effects of electromagnetic activity on adult fishes may not be the same as early life stages (e.g., eggs, larvae, juveniles) due to lifestage-based shifts in habitat utilization (Botsford et al. 2009; Sabates et al. 2007). For example, some skates and rays produce egg cases that lay on the bottom of the seafloor, while many neonate and adult sharks occur in the water column or near the water surface. Therefore, exposure of eggs and larvae to electromagnetic fields during Navy activities would be low since the distributions of the devices are patchy.

Although some individual fish species may exhibit a response to electromagnetic exposure, the fields generated are typically well below physiological and behavioral responses of magnetoreceptive fishes. The strength of the electromagnetic devices used by the Navy is relatively minute and quickly dissipates at short distances away from the source. The devices work by emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. The magnetic field away from the device is comparable to the Earth's magnetic field (see sea turtle section above). Based on the small area around each electromagnetic device that will have an altered magnetic field, we assume that any potential disruption in an individual fish's orientation ability in the action area would only occur very close to the source. Additionally, this disruption would be temporary and last only as long as the fish remains within the area where the magnetic field is altered, which is likely to be very brief. Furthermore, most fishes would be expected to avoid the device prior to entering the area where the magnetic field would be altered. NMFS considers it extremely unlikely that ESA-listed fish would be exposed to electromagnetic energy at sufficient intensities to create an adverse effect through behavioral disruption or otherwise. Therefore, potential effects from electromagnetic devices are discountable.

9.1.3.2.2 Lasers – Fishes

For ESA-listed fishes, NMFS considers the potential for a high energy laser to strike an individual unlikely. The potential for exposure to a high energy laser beam decreases deeper in the water column, so most fish are unlikely to be exposed to laser activities that typically occur a few meters below the sea surface. ESA-listed species such as Atlantic salmon, Gulf sturgeon, Nassau grouper, and the Central and Southwest Atlantic DPS of the scalloped hammerhead shark will not occur in the areas where lasers will be used. Atlantic sturgeon, shortnose sturgeon, and smalltooth sawfish typically occur in the lower depths of the water column or near the seafloor. Therefore, NMFS does not anticipate these species to be close enough to a laser to be at risk of injury. ESA-listed fish species in these areas that could occur at or near the surface would be oceanic whitetip sharks and giant manta rays, although the likelihood of being hit by a laser is extremely low due to the limited number of activities involving lasers (four times annually), and the large size of the action area, make it unlikely that an individual fish would be hit. Furthermore, any harm to a fish would only occur if the laser beam missed the target, which has a low probability of occurrence based on information from past Navy exercises that were the subject of previous consultations. For these reasons, the effects of the use of high energy lasers on fishes are considered discountable.

9.1.3.3 Physical Disturbance and Strike Stressors – Fishes

Additional discussion on physical disturbance and strike stressors is included in Section 6.4. This section analyzes the potential impacts of the various types of physical disturbance, including the potential for strike, during training and testing activities within the action area from military expended materials, including non-explosive practice munitions and fragments from high-explosive munitions, and seafloor devices.

9.1.3.3.1 Military Expended Materials – Fishes

For ESA-listed fishes that may occur in the action area during Navy training and testing activities, various items may be introduced and expended into the water column including non-explosive practice munitions, fragments from high-explosive munitions, expendable targets, and expended materials other than munitions such as sonobuoys, expended bathythermographs, and torpedo accessories. Although the Navy was able to complete quantitative analysis for marine mammals and sea turtles to determine the likelihood of a strike of these species by military expended materials, they were unable to do this for fishes. This is primarily due to the lack of fish density and distribution data for all of the species potentially affected in the large action area.

In the absence of this data, the Navy and NMFS completed a more qualitative assessment based upon areas where activities will occur, the number of occurrences annually, and fish species' life history patterns, which help to predict presence in the action area according to preferred habitats, season and lifestage. The Navy developed qualitative "footprints" for each type of military expended material is described in Appendix F of the AFTT DEIS/OEIS (Navy 2017c).

Although it is possible for fishes to be struck by military expended materials as they sink through the water column, this likelihood of a fish being hit by material is highly unlikely for most materials since fishes are capable of detecting sinking objects and moving away from them. Therefore, with the exception of sinking exercises (they occur at depths of 3,000 m) the discussion of military expended materials that may strike fishes focuses on those objects that could affect fishes located at or near the surface of the water column, which would primarily be fragments from high-explosives and projectiles.

Most of the expended material that may enter the water column is expected to only cause temporary, localized impacts when striking the surface of the water. Current Navy gunnery exercises include firing a variety of weapons and using a variety of non-explosive training and testing rounds, including 5-inch naval gun shells and small-, medium-, and large-caliber projectiles. The larger-caliber projectiles are only used in the open ocean beyond 20 NM. There is a remote possibility that an individual fish at or near the surface could be struck by any of these projectiles, and if a fish were to be hit it would likely be killed or injured. As these materials sink in the water column and eventually settle, they are expected to land 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, but not become resuspended in the water column. It is conceivable then for any benthic oriented fish to be startled by objects sinking and settling in the sediments.

Bombs, missiles, and rockets are potential physical disturbance and strike stressors to fishes. Most missiles either hit their target or are disabled before hitting the water. Thus, missiles and aerial targets are fragmented when they enter the water, and these smaller fragments quickly lose velocity as they hit the water, decreasing risks of a fish being hit as they presumably could move away from these fragments. In addition, the Navy "footprint" analysis for these stressor effects on fishes assumes that any fish present in the action area either occupy the water surface (e.g., salmonids, pelagic sharks and manta rays) or near the substrate along the seafloor (e.g., sturgeon, sawfish, Nassau grouper).

Fragments produced by exploding bombs could potentially hit fish and cause injury or death (Stuhmiller et al. 1990). However, studies of underwater bomb blasts show that fragments are large and decelerate rapidly (O'keeffe and Young 1984; Swisdak Jr. and Montaro 1992), posing little risk to fish located in the water column near the sinking fragments. Moreover, because the area of the water column would be very small compared to the vast open ocean areas of the action area, the anticipated reaction of fishes are likely to be avoidance of the explosive material and leaving the area where bombing is occurring, which would reduce the risk of a fish sustaining a strike once the expended materials hit the water surface. Any type of avoidance behavior is expected to be temporary with behavior returning to normal once the fish is out of range or the disturbance concludes.

NMFS considered the Navy's rationale and analysis of effects from these stressors on fishes and agree ESA-listed fish species the most susceptible to military expended material strikes are those occurring at the surface, within the offshore and continental shelf portions of the Naval range complexes (where the strike would occur). These species include Atlantic salmon, oceanic whitetip sharks, scalloped hammerhead sharks, and giant manta rays. Fish species considered less susceptible to the risk of being hit by expended materials are those fish species located along the ocean substrate and exposed to expended items that sink and settle on the seafloor (e.g., Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, and Nassau grouper). As an item descends through the water column, the speed with which it sinks slows, thus a fish can presumably move away from the object and avoid being hit. Fishes located just below the water's surface are also considered capable of detecting and avoiding approaching munitions or fragments that fall through the water column. Even for an unlikely, but extreme scenario of the Navy expending all small-caliber projectiles within a single gunnery box, the probability of any of these items striking a fish, even larger fishes, is extremely low. A more likely response of fishes would be a brief behavioral disturbance as a fish avoids or moves away from an item that sinks in the water or settles on the seafloor. For these reasons, NMFS considers the risk for ESA-listed fish species to be affected by Navy activities that produce military expended materials extremely low, and therefore discountable.

9.1.3.3.2 Seafloor Devices – Fishes

Seafloor devices would be deployed in the Virginia Capes Range Complex, Navy Cherry Point Range Complex, Jacksonville Range Complex, Key West Range Complex, Gulf of Mexico Range Complex, and Naval Surface Warfare Center Panama City Testing Range, in addition to a large number of inshore waters. For ESA-listed fish species in these areas, seafloor devices (moored mine shapes, recoverable anchors, bottom-placed instruments, and bottom crawl vehicles) may potentially strike or disturb fishes located in the water-column as the device descends, or as it settles or moves across the seafloor. Because some fish species are known to investigate and forage near objects in the water column, or to use stationary objects for sheltering, they could be attracted to a seafloor device, such as a non-explosive mine assembly. However, because the seafloor devices that are not stationary move very slowly, and fish are expected to be able to detect and avoid objects moving through the water column, so a fish being injured or otherwise harmed by one of these devices is extremely unlikely.

In addition, the Navy will implement mitigation measures for some seafloor devices such as precision anchoring. These measures will avoid precision anchoring within the anchor swing circle of shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks which may help avoid some potential impacts on those fish species that could be located in these areas such (e.g. Nassau grouper), but only for those fish species that inhabit these areas. NMFS assumes any seafloor devices have the potential of a fish encountering them in the water column as an object sinks, or along the substrate after it settles or along the substrate as the device moves (in the case of bottom crawl vehicles). However, for the reasons described above, NMFS does not expect fish to be harmed by these devices, nor are fish expected to alter their behavior to a measurable extent. Therefore, NMFS considers the effects on ESA-listed fishes from exposure to seafloor devices discountable.

9.1.3.4 Entanglement Stressors – Fishes

All of the ESA-listed fish species present within the action area could encounter materials that have the potential to entangle them such as decelerators and parachutes or wires and cables that are used during Navy activities. Fish species could encounter these items at the water's surface, in the water column, or along the seafloor. Many factors may influence the degree of entanglement risk for fishes such as and life stage and size, sensory capabilities, and foraging methods (i.e. along the seafloor or in the water column). Similar to other marine animals, most entanglements associated with fishes are from fishing gear (as opposed to military items) that float or are suspended at the ocean's surface for long periods of time.

For the vast majority of ESA-listed fishes considered in this biological opinion, the potential risk of entanglement is considered very low due to body shape/size. However, some species of fish are more susceptible to entanglement in derelict fishing gear and other marine debris, compared to other fish groups. For example, the physical features such as the rigid scutes or the protruding bony projections of sturgeon or the shape of the body of some elasmobranchs such as manta rays, increase their risk of entanglement compared to fishes with smoother, more streamlined bodies such as Atlantic salmon. For these reasons, Atlantic sturgeon and Giant manta ray have a higher degree of risk associated with entanglement from decelerators and parachutes, and therefore these two species are discussed separately below.

For most of the pelagic species of fish such as Atlantic salmon and oceanic whitetip sharks, the risk of entanglement is low given their body shape and ability to avoid materials that could entangle them in the water column. Atlantic salmon are very strong swimmers, with a streamlined body that is unlikely to become entangled in decelerators and parachutes or lines. Oceanic white tip sharks occurring offshore could come into contact with a decelerator and parachute, however, as with salmon, these sharks are highly mobile and visual predators that could easily avoid floating or suspended materials or break free if entangled. Moreover, the small and medium sized chutes that would most likely be encountered by sharks would sink fairly quickly and therefore would not pose as significant of a threat to an oceanic whitetip shark.

Fish that are located along benthic substrates, or near reefs, could also encounter decelerators, parachutes or other wires and lines. Only a single large decelerator/parachute will be deployed in the Gulf of Mexico Range Complex annually, so the likelihood of an encounter between a Gulf sturgeon and an expended decelerator and parachute is considered extremely unlikely and discountable. Smalltooth sawfish may encounter decelerators and parachutes in a very limited area within the vast action areas along around the Florida peninsula, but potentially in the Navy Cherry Point Range Complex. Given their unique saw-like rostrum, the potential for smalltooth sawfish to become entangled is greater than for other fish species. However, sawfishes are highly mobile, visual predators, and are expected to be able to detect and easily avoid a floating decelerator and parachute. Therefore, entanglement is considered extremely unlikely for smalltooth sawfish.

Shortnose sturgeon primarily occur in riverine habitats outside of the action area, therefore encounters with decelerators and parachutes from Navy activities would be rare. Shortnose sturgeon do make occasional excursions into estuarine and coastal marine waters and could potentially encounter cables and wires primarily in the Northeast, Navy Cherry Point, and Jacksonville Range Complexes, although this is unlikely as most Navy activities involving the use of decelerators and parachutes would be conducted further offshore beyond the zone where this species is expected to occur. Nassau groupers are found in reef areas of the Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea and could encounter decelerators and parachutes, however, because this species is also highly mobile and considered capable of avoiding any sinking or settled material, entanglement would also be unlikely for this species. Scalloped hammerhead sharks of the Central and Southwest Atlantic DPSs only would occur in the action area during Navy activities in the vicinity of Puerto Rico and the southeastern portion of the KWRC. As with other sharks and groupers described above, scalloped hammerhead sharks are a highly mobile species that could avoid floating or suspended decelerators and parachutes. Only small and medium-sized parachutes would potentially be expended in areas where scalloped hammerhead sharks occur, which decrease the risk of entanglement, making the probability of entanglement for scalloped hammerhead shark extremely low.

Although some species of fishes could also become entangled in the guidance wires and fiber optic cables, the risk for most of the fish species is considered extremely low. A portion of the fiber optic cables used by the Navy may be recovered, but some used for remotely operated mine neutralization activities would not. The length of this expended tactical fiber would vary (up to about 3,000 m) depending on the activity. Tactical fiber has an 8-micrometer (0.008 millimeters) silica core and acylate coating and looks and feels like thin monofilament fishing line; tactical fiber is relatively brittle and breaks if knotted, kinked, or abraded against a sharp object (Navy 2017a). Therefore, if this becomes looped around an underwater object or animal, it is unlikely to tighten. Although this material will not be recovered, it is expected to only remain in the water column for a short duration, and ultimately sink. Similarly, once a guidance wire is released it is expected to rapidly sink, settle and remain on the seafloor. If a wire were to snag or be partially resuspended, in theory a fish could swim through loops in the wire that may entangle the fish. However, because of their rigidity and size, loops are less likely to form in a guidance wire or sonobuoy wire (Group 2005). Torpedo guidance wire is resistant to looping and coiling suggesting it has a low entanglement potential compared to other entanglement hazards (Mcdonald and J. 2013). Similarly, fiber optic wire material is more resistant to forming loops and would easily break when tightly kinked or bent at a sharp angle. Compared to fishing gear materials which are more common entanglement threats for fishes; and have breaking strengths much greater than that of guidance wire and fiber optic cables used during Navy activities. For the reasons described above, primarily the physical properties of the wires and cables used, the risk of entanglement from wires is very low.

Similarly, sonobuoy surface antenna, float unit, and subsurface hydrophone are attached through a thin gauge, dual-conductor, and hard-draw copper strand wire; which is wrapped by a hollow rubber tubing or bungee. The tensile breaking strength of the wire and rubber tubing is no more than 40 pounds. 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. This nylon fabric is very thin and can be broken by hand; therefore, it does not pose a risk of entanglement for fish. Sonobuoys may remain suspended in the water column for no more than 30 hours, after which they sink to the seafloor. Sonobuoy wires may be expended within any of the range complexes throughout the action area. However, the wire that runs through the stabilizing system and leads to the hydrophone components of the sonobuoy hangs vertically in the water column, reducing the risk of ESA-listed fishes becoming entangled.

The materials associated with parachutes and decelerators can be potentially encountered by fishes at the sea surface, in the water column, or on the seafloor. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with these materials have the potential to result in mortality, adverse sub-lethal effects, and behavioral responses if a fish encounters them. Fish species that could be susceptible to entanglement in decelerators and parachutes are the same as discussed above for cables and wires.

Throughout the action area, the vast majority of expended decelerator and parachutes are small (18 inches) cruciform shaped decelerators used with sonobuoys. They have short attachment lines and, upon water impact, may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the seafloor. Entanglement of an animal in a parachute assembly at the surface or within the water column would be unlikely, since the parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. It is possible that a benthic-feeding animal (e.g., sturgeon) could become entangled when they are foraging in areas where parachutes have settled on the benthic substrate. For example, if bottom currents are present, the canopy may temporarily billow and pose a greater entanglement threat. However, the likelihood of currents causing a billowing of a parachute and being encountered by an ESA-listed sturgeon species is remote. For the reasons described for sea turtles, these materials that settle on the benthos are expected to become covered with sediment or organisms over time, or degrade within a few years and no longer pose a risk of entanglement.

For the large and extra-large decelerator and parachutes, which are unweighted and have multiple long lines attached to them, the chance of an entanglement is greater for Atlantic Sturgeon and giant manta rays, which are discussed below.

Atlantic Sturgeon – Large and Extra-large Parachutes

All of the five DPSs of Atlantic sturgeon that occur in the action area may co-occur training and testing activities that involve the use of decelerators and parachutes. Atlantic sturgeon may encounter expended decelerators and parachutes in the water column and seafloor from training and testing activities along the continental shelf in the Northeast, Virginia Capes, Navy Cherry Point, Jacksonville Range Complexes, and the Naval Undersea Warfare Center Newport Testing Range.

Of the four sizes of parachutes that Atlantic sturgeon may encounter, the large and extra-large parachutes likely pose the greatest risk of entanglement to sturgeon. The small decelerators and parachutes likely pose less of a risk due to their smaller size, because they are primarily used in deeper waters, have a faster sink rate, and are dispersed widely throughout the action area (i.e. not concentrated in high numbers in specific areas) in locations where most sturgeon are unlikely to occur. All five DPSs of Atlantic Sturgeon are known to congregate in large numbers off the coast of Virginia during the winter months, and are present during coastal migration periods in the nearshore waters off the coast of Virginia during the spring and fall (Hager 2016; NMFS 2007; Watterson et al. 2017). While NMFS considers the chance of an encounter with these larger sized parachutes to be remote due to low numbers deployed each year, the large size of the canopy and number and length (28 to 64 lines up to up to 60 to 82 ft long) of lines associated with them combined with the physical attributes of sturgeon such as ridges and scutes increase the potential of entanglement should an encounter occur compared to other fish species. Additionally, these sized parachutes and decelerators are not weighted with anything to help them sink rapidly, thus they could potentially remain suspended in the water column for an extended period of time, increasing the chance of sturgeon encountering them in the water column.

However, a relatively small number of these parachutes will be deployed (i.e., 50 large and 5 extra large), which decreases the potential for a sturgeon to encounter one. Additionally, efforts are made to recover large and extra large parachutes. The small number of large and extra large parachutes proposed for use annually and the fact that some of these parachutes are recovered reduces the potential for Atlantic sturgeon to encounter and become entangled in these items. Furthermore, because the structure and light-weight nature of these materials differs from fishing gear such as heavy lines or netting (which has a greater entanglement risk), the chances of a sturgeon actually becoming entangled is extremely low. Atlantic sturgeon would likely be able to visually detect and avoid long lines and large parachutes sinking through the water column. In addition, because these fish typically inhabit areas along the substrate, they are more likely to encounter a parachute and decelerator assembly that has already settled, and thus less likely to become entangled for the reasons described above regarding items that settle on the seafloor (e.g., parachutes that settle on the benthos are expected to become covered with sediment or organisms over time). While the physical attributes of Atlantic sturgeon place them at higher risk of entanglement than other fish species, the risk of entanglement of Atlantic sturgeon by parachutes and decelerators is extremely low and therefore discountable for this species.

Giant Manta Ray – Large and Extra-large Parachutes

Giant manta rays have the potential to be present anywhere in the action area with the Gulf and Atlantic coast as far north as New Jersey. During Navy training and testing activities, giant manta ray have the potential to be present in most areas where training activities involving the use of decelerators and parachutes occur and manta rays are known to be susceptible to entanglement. A study in Hawaii found 10% of manta rays (28 individuals out of a sample of 290) had cephalic fins (fins on either side of the mouth) amputated, disfigured, or were non-functioning (Deakos et al. 2011), apparently due to entanglement in monofilament fishing line. Other evidence has documented mortality of manta rays from entanglement with anchor and mooring lines (Bigelow and Schroeder 1953; Deakos et al. 2011).

Manta ray susceptibility to entanglement is largely due to their unique body shape, particularly their cephalic fins. However, manta rays are highly mobile species that are expected to be able to avoid the small or medium-sized floating or suspended decelerators and parachutes, which comprise the majority of the decelerators and parachutes used in the action areas. Furthermore, as discussed above with sturgeon, these small and medium decelerators and parachutes have weights attached, causing a more rapid sink rate, thereby decreasing the amount of time materials float at the surface, reducing the risk of a giant manta ray encountering them.

As with Atlantic sturgeon, it is the large and extra-large decelerators and parachutes that may pose a higher degree of risk for manta rays since these chutes are larger and have long lines (large chutes have 28 cords, approximately 40 to 70 ft long; extra-large chutes have 64 cords, up to 82 ft long) associated with them. Additionally, these parachutes are not weighted with anything to help them sink rapidly, and could potentially remain suspended in the water column for an extended period of time. While the chance of an encounter is remote given the small number of the large and extra-large chutes proposed to be deployed, the large size of the chutes and attached cords, and physical shape of the fish, increase giant manta ray's susceptibility to entanglement make the risk of entanglement greater for this species compared to other fishes considered in this opinion. Given the vast area over which any one of these large decelerators and parachutes would be deployed, and the limited number of them deployed annually, the chances of any fish encountering them and becoming entangled is decreased. Additionally, available data indicates the entanglements and injuries described for this species are mostly due to exposure to fishing gear such as monofilament lines and large heavy mooring lines. The materials of parachutes and decelerators and lines are not the same as monofilament, and are more likely to sink over some period of time and ultimately settle on the seafloor. In contrast to parachutes, monofilament lines are hard to see for fishes and can float indefinitely in the water column unless they become attached to something that anchors them or causes them to sink. They also can easily form multiple loops. Mooring lines are quite heavy and likely more difficult for animal to release itself from should it become ensnared in a mooring line. Furthermore, no cases of fish entanglement have been reported for parachutes (Ocean Conservancy 2010; U.S. Department of the Navy 2001). While NMFS recognizes there is a higher risk of entanglement for giant manta rays than for other fish species, we consider giant manta rays able to visually detect and avoid descending or sinking parachutes in the water column. This is expected to result in a minor behavioral response. Therefore due to the extremely low probability of a giant manta ray becoming entangled in parachute and decelerators, NMFS considers the effects from this stressor discountable for giant manta rays.

In summary, the likelihood of ESA-listed fish species becoming entangled with material such as parachutes and decelerators, fiber optic cables and lines is extremely low. Therefore, NMFS considers the effect from these stressors to be discountable for all ESA-listed fish species considered in this opinion.

9.1.3.5 Ingestion Stressors – Fishes

For ESA-listed fishes occurring in the action area, it is reasonable to assume that any item of a size that can be swallowed by a fish could be eaten at some time. Given the life histories and foraging strategies of the fish species considered in this opinion, ingestion of materials could occur at water surface, in the water column, and on the seafloor. The potential for ESA-listed fish species to encounter and ingest expended materials is also evaluated with respect to their physical size and geographic range, which could also influence the probability that they would consume military expended materials.

Fish are known to ingest a variety of small items in the marine environment, including metal and plastics. Metal items eaten by marine fish are generally small (such as fish hooks, bottle caps, and metal springs), suggesting that small and medium caliber projectiles, pistons, or end caps (from chaff canisters or flares) are more likely to be ingested. Both physical and toxicological impacts could occur as a result of consuming metal or plastic materials (Davison and Asch 2011; Navy 2017a). Plastics in particular have been shown to increase hazardous toxic burden in fish leading to organ (e.g. liver) toxicity (Rochman et al. 2013). The military expended materials that could potentially impact pelagic species that feed 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., end caps and pistons from chaff cartridges or flares). 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).

As previously described, the Navy expends the following types of materials during training and testing in the action area that could become ingestion stressors: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, and fragments from targets, chaff, flare casings (including plastic end caps and pistons). In the Navy's analysis and in this biological opinion, only small- and medium-caliber munitions (or small fragments from larger munitions), chaff, and end caps and pistons from flares and chaff cartridges are considered to be of ingestible size for a fish. Small- and medium-caliber projectiles include all sizes up to and including 2.25-inch 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. In addition, these fragments may also be accidentally ingested by fishes that forage on the bottom such as sturgeon and sawfish. Small-caliber projectiles would likely be more prevalent throughout the action area and thus more likely to be encountered and potentially ingested by bottom-dwelling and some reef fishes, such as Nassau grouper, than fragments from any type of high-explosive munitions. For many small fish species and juvenile fishes, most of these items (with the exception of chaff) are too large to be ingested. If a larval or juvenile fish swallows chaff, studies have shown it to have limited effects on fishes due to the concentration levels at which it is released (Arfsten et al. 2002; Force 1997; Spargo 1999). No ingestion impacts on early life stages of fishes are likely to occur, with the exception of large juveniles that may be large enough to ingest military expended materials. Therefore, the discussion in this section focuses on those ESA-listed fish species large enough to potentially ingest these materials.

Open-ocean, pelagic fish such as Atlantic salmon and oceanic whitetip sharks, and open-ocean planktivores such as giant manta rays are more likely to ingest materials floating in the water column. However, because giant manta rays are filter-feeders, they are not expected to intentionally ingest munitions. Atlantic salmon only occur in the northern portions of the Northeast Range Complexes and would only encounter munitions in this area. Due to the size and composition of material that enters the water where Atlantic salmon or other pelagic species such as oceanic white tip sharks and giant manta rays may be located, the munitions and fragments would sink fairly rapidly to the seafloor. This would limit the time available for pelagic species to encounter and ingest these items. While the most likely scenario would be for Atlantic salmon to ignore these objects, if a salmon did ingest a fragment or other munition, it would most likely taste the item, then spit it out (Felix et al. 1995). Oceanic whitetip sharks are considered scarce in the action area, which would decrease their chance of encountering sinking material in the water column. Once the item sinks to the seafloor, it would be unavailable to oceanic whitetip sharks. As with the other pelagic species, if an item were accidentally ingested by a shark, it would likely expel the item after it was determined to not be a prey item.

Coastal and estuarine epibenthic or benthic-dwelling fishes such as sturgeon, scalloped hammerhead sharks, smalltooth sawfishes, and Nassau grouper could ingest materials from the seafloor. Nassau grouper are opportunistic ambush predators, and prefer to feed on moving prey such as fishes, shrimps, crabs, lobsters, and octopuses. Because they are ambush predators, they may strike at small munitions as they descend through the water column, potentially mistaking them for prey. Similar to salmon, once they taste and determine the item is not prey, they are likely to expel the item. Scalloped hammerhead sharks have the potential to encounter training and testing activities involving the use of military expended materials within in the KWRC. However, scalloped hammerhead sharks have an extremely developed sense of electroreception, making it is unlikely they would mistake expended munitions for prey. Smalltooth sawfish primarily inhabit nearshore habitats in southern Florida and other gulf coast locations, such as seagrass beds and mangroves. Smalltooth sawfish adults may inhabit reefs in deeper waters. However, the potential impacts on smalltooth sawfish from ingestion are not likely to occur because they rarely occur in the locations where munitions are expended by the Navy. The likelihood of ingestion of munitions or fragments by early life stages of sawfish would be even less than that of adults because nursery habitats are found in very shallow water (less than 1 m) where no munitions will be expended.

All DPSs of Atlantic sturgeon and Gulf sturgeon may occur in portions of the action area out to the continental shelf break where projectiles and munitions are used. For these reasons, Navy activities expending projectiles or munitions could expose Atlantic and Gulf sturgeon to ingestion risk. All sturgeon in the action area are benthic feeders and suction-feed along the bottom in coastal waters on small fish and invertebrates. Because of their feeding habits, sturgeon have a higher probability of ingesting material that has settled or is mixed with sediment on the seafloor (Ross et al. 2009 as cited in Navy 2017a). Juvenile sturgeon are not expected to be in the areas where expended materials are present, so these life stages are not expected to be exposed to ingestion stressors; only sub-adults and adult sturgeon would be potentially exposed to ingestion stressors. If a sturgeon ingested a small-caliber projectile or fragment, it is not expected to result in adverse impacts to the animal because the size of the material is not expected to cause blockage or exert other deleterious health effects. Small-caliber casing are smooth and not expected to cause internal digestive complications as sturgeon typically eat and pass hard-bodied prey items such as mollusks and crustaceans.

For the reasons provided above, we consider it extremely unlikely that ESA-listed fish species would ingest materials resulting in adverse effects to the fish's normal behavior, growth, survival, or reproductive success. Therefore, the risk of ingestion of expended materials is considered discountable for all ESA-listed fish species considered in this biological opinion.

9.1.4 Secondary Stressors – Marine Mammals, Sea Turtles, and Fishes

This section analyzes potential impacts to ESA-listed marine mammals, sea turtles, and fish exposed to stressors indirectly through impacts to their habitat or prey or through the introduction of parasites or disease. The stressors evaluated in this section include (1) explosives 2) explosive byproducts and unexploded munitions, (3) metals, (4) chemicals, and (5) transmission of disease and parasites. Secondary stressors are analyzed collectively for these taxa because the potential effects are the same across all of these taxa.

Explosives

Underwater explosions could impact other species in the food web, including prey species that marine mammals, sea turtles, and fish feed upon. The impacts of explosions would differ depending on the type of prey species in the area of the blast. In addition to physical effects of an underwater blast, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to explosions that might include swimming to the surface or scattering away from the source. This startle and flight response is the most common secondary defense among animals (Hanlon and Messenger 1996; Mather 2004). The abundances of prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. Alternatively, any prey species that would be directly injured or killed by the blast could draw in scavengers from the surrounding waters that would feed on those organisms, and in turn could be susceptible to becoming directly injured or killed by subsequent explosions. Any of these scenarios would be temporary, only occurring during activities involving explosives, and no lasting effect on prey availability or the pelagic food web would be expected.

Explosive Byproducts and Unexploded Munitions[22]

High-order explosions (i.e., a successful explosion or an explosion that produces the intended result) consume almost all of the explosive material in the ordnance, leaving little to no material in the environment that could potentially affect marine species or their habitats. On the other hand, low order detonations and unexploded munitions leave more explosive material in the environment. Lotufo et al. (2010) studied the potential toxicity of Royal Demolition Explosive byproducts to marine organisms. The authors concluded that degradation products of this explosive are not toxic at realistic exposure levels. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6 to 12 inches away from degrading munitions, the concentrations of these compounds were not statistically distinguishable from background beyond 3 to 6 ft from the degrading munitions. Taken together, it is possible that ESA-listed marine mammals, sea turtles, and fish could be exposed to degrading explosives, but it would be within a very small radius of the explosive (1 to 6 ft).

A series of research efforts focused on World War II underwater munitions disposal sites in Hawaii (Briggs et al. 2016; Edwards and coauthors. 2016; Kelley et al. 2016; Koide et al. 2016) and an intensively used live fire range in the Mariana Islands (Smith and Marx Jr. 2016) provide information in regard to the impacts of undetonated materials and unexploded munitions on marine life. 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.

[22] Note that the potential effects of unexploded munitions on ESA-listed corals is described in section 9.1.5.6 of this opinion.

The island of Farallon De Medinilla (in the Mariana Islands) has been used as a target area since 1971. Between 1997 and 2012, there were 14 underwater scientific survey investigations around the island providing a long term look at potential impacts on the marine life from training and testing involving the use of munitions (Smith and Marx Jr. 2016). Munitions use has included high-explosive rounds from gunfire, high-explosives bombs by Navy aircraft and U.S. Air Force B-52s, in addition to the expenditure of inert rounds and non-explosive practice bombs. Marine life assessed during these surveys included algae, corals, benthic invertebrates, sharks, rays, and bony fishes, and sea turtles. The investigators found no evidence over the 16-year period, that the condition of the biological resources had been adversely impacted to a significant degree by the training activities (Smith and Marx Jr. 2016). Furthermore, they found that the health, abundance, and biomass of fishes, corals and other marine resources were comparable to or superior to those in similar habitats at other locations within the Mariana Archipelago.

These findings are consistent with other assessments such as that done for the Potomac River Test Range at Dahlgren, Virginia which was established in 1918 and is the nation's largest fully instrumented, over-the-water gun-firing range. Munitions tested at Naval Surface Warfare Center, Dahlgren have included rounds from small-caliber guns up to the Navy's largest (16 inch guns), bombs, rockets, mortars, grenades, mines, depth charges, and torpedoes (Navy 2013c). Results from the assessment indicate that munitions expended at Naval Surface Warfare Center, Dahlgren have not contributed to significant concentrations of metals to the Potomac River water and sediments given those contributions are orders of magnitude less than concentrations already present in the Potomac River from natural and other manmade sources (Navy 2013c).

The concentration of munitions/explosions, expended material, or devices in any one location in the action area are expected to be a small fraction of that from the sites described above. As a result, explosion by-products and unexploded munitions are not anticipated to have adverse effects on water quality or prey abundance in the action area. For this reason, the effects of explosive byproducts and unexploded munitions on marine mammals, sea turtles, and fish are insignificant.

Metals

Metals are introduced into seawater and sediments as a result of training and testing activities involving ship hulks, targets, munitions, and other military expended materials (Environmental Sciences Group, 2005). Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. Evidence from a number of studies (Briggs et al. 2016; Edwards and coauthors. 2016; Kelley et al. 2016; Koide et al. 2016; Navy 2013c) indicate metal contamination is very localized and that bioaccumulation resulting from munitions cannot be demonstrated. Specifically, in sampled marine life living on or around munitions on the seafloor, metal concentrations could not be definitively linked to the munitions since comparison of metals in sediment next to munitions show relatively little difference in comparison to other "clean" marine sediments used as a control/reference (Koide et al. 2016). Research has demonstrated that some smaller marine organisms are attracted to metal munitions as a hard substrate for colonization or as shelter (Kelley et al. 2016; Smith and Marx Jr. 2016), but this would not have an effect on the availability of marine mammal prey. The research cited above indicates that metals introduced into the action area are unlikely to have adverse effects on ESA-listed marine mammal, sea turtle, or fish prey or habitat. For these reasons, the metals introduced into seawater and sediments would have an insignificant effect on these species.

Chemicals

Several Navy training and testing activities introduce chemicals into the marine environment that are potentially harmful in higher concentrations. However, rapid dilution would be expected and toxic concentrations are unlikely to be encountered by ESA-listed marine mammals, sea turtles, fish, or their prey. Chemicals introduced are principally from flares and propellants for missiles and torpedoes. Properly functioning flares, missiles, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures may allow propellants and their degradation products to be released into the marine environment. Flares and missiles that operationally fail may release perchlorate, which is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals if in sufficient concentration. However, such concentrations would be localized and are not likely to persist in the ocean. Research has demonstrated that perchlorate did not bio concentrate or bioaccumulate, which was consistent with the expectations for a water-soluble compound (Furin et al. 2013). Perchlorate from failed expendable items is therefore unlikely to compromise water quality to that point that it would act as a secondary stressor to marine mammals, sea turtles, and fishes. For these reasons, the effects of chemicals used during Navy training and testing are insignificant and not likely to adversely affect ESA-listed marine mammals, sea turtles, or fish species.

Transmission of Disease and Parasites

The primary vector through which parasites or disease would be transferred to new locations and the ESA-listed species there would be through the deployment of marine mammals used by the Navy’s Marine Mammal Systems. Navy animals receive regular veterinarian care, including predeployment exams, regular deworming, and regional screening for specific pathogens of interest (Navy 2017a). The animals are fed restaurant-quality fish to minimize the likelihood of parasite ingestion and animal waste is collected and managed to control the potential spread of parasites. Prior to animal deployment Navy personnel observe the surrounding area and if wild marine mammals are spotted animal deployment is delayed. Contact between Navy animals and wild animals is minimized to the greatest extent possible. In the 40 years the Marine Mammal Program has been operating there has been no known disease or parasite transmissions from Navy animals to wild animals (Navy 2017a). Given the care Navy animals receive, the waste disposal protocols, the minimal time Navy animals are in contact with wild animals, the likelihood that parasites or diseases will be transferred to ESA-listed marine mammals is discountable.

9.1.5 Corals and Elkhorn and Staghorn Coral Critical Habitat

We determined that all acoustic stressors, explosive stressors, energy stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect ESA-listed corals and designated elkhorn and staghorn coral critical habitat. As noted above, our analysis for these stressors is organized on the taxa level (i.e., corals) because the pathways for effects for these stressors is generally similar for all corals. While there is variation among species within each taxa, the coral species considered in this opinion share many similar life history patterns and other factors (e.g., morphology) which make them similarly vulnerable (or not) to the stressors associated with the proposed action. Where species-specific information is relevant, this information is provided in this section. Our analysis for these stressors and corals is summarized below.

9.1.5.1 Acoustic Stressors – Corals

Additional discussion on acoustic stressors is included in Section 6.1. The Navy determined that acoustic stressors would have no effect on ESA-listed corals in the action area. Adult coral colonies are not biologically capable of detecting noise except as vibrations of water particles. The only known auditory sensing capabilities for coral is the response of free-swimming coral larvae to underwater sounds produced by reef fish and crustaceans, as reported by Vermeij et al. (2010). The authors reported that some species of coral larvae detect reef sounds and then show an attraction response to the sounds generated on the reefs. However, potential interference in the ability of coral larvae to detect reef sounds would be temporary, lasting only the duration that the acoustic source is turned on or that the vessel is transiting the area and is in the vicinity of the larval coral. We do not expect these brief interruptions to inhibit the ability of coral larvae to detect reef habitat for settlement. Therefore, we have determined that the effects of acoustic stressors on ESA-listed corals are insignificant (i.e., so minor that the effect cannot be reasonably evaluated) and acoustic stressors are not likely to adversely affect these species.

9.1.5.2 Energy Stressors – Corals

Additional discussion on energy stressors is included in Section 6.3. The Navy determined that energy stressors would have no effect on ESA-listed corals. Reef-building corals grown in an electromagnetic field generally have higher growth rates and less mortality as shown by experimental studies with *Acropora pulchra* and *Acropora yongei* (Borell et al. 2010). Electromagnetic fields presumably aid in the accretion of calcium carbonate, allowing reef-building corals to grow at a faster rate. Therefore, ESA-listed corals are not expected to experience negative effects from the use of electromagnetic devices. For this reason, effects of the use of electromagnetic devices during Navy training and testing on ESA-listed corals will be insignificant.

9.1.5.3 Explosive Stressors – Corals

As described previously in Section 6.2, explosives include, but are not limited to, missiles, torpedoes, medium and large caliber projectiles, mines, demolition charges, and explosive sonobuoys. Activities involving the use of high-explosive munitions, including bombs, missiles, and medium and large caliber projectiles could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys could occur in the water column, and mines and demolition charges could be detonated in the water column or on the ocean bottom.

Detonations may impact sexually mature coral colonies depending on the size and location of the blast radius of the explosion in relation to the coral colonies. Additionally, if explosives are used during mass spawning of elkhorn, staghorn, pillar, lobed star, mountainous star, and boulder star corals (associated with the first full moon of August, September, and/or October depending on the coral species), coral larvae could be impacted. Modeling of coral larval transport demonstrates that, based on spawning sites including along the east coast of South Florida, the Florida Keys, and Flower Garden Banks, there are passive connections with the Caribbean (islands and Latin America) and the Atlantic coasts of Caribbean islands such as Cuba, and the Yucatan coast of Mexico, among others. Additionally, elkhorn and staghorn coral critical habitat could be directly impacted by detonations or experience some level of structural degradation depending on the size and location of the blast radius of the explosion in relation to critical habitat.

Most training and testing activities that take place in locations where ESA-listed corals occur are conducted at KWRC and SFOMF (Figure 8). Elkhorn and staghorn coral critical habitat (Florida unit) is also present in these areas, with the exception of a small area within the SFOMF and the area subject to the Naval Air Station Key West Integrated Natural Resources Management Plan (within 50 yards of shore). The action area also includes the Flower Garden Banks in the Gulf of Mexico where most of the ESA-listed Atlantic/Caribbean coral species have been observed, and the U.S. Caribbean where all seven species of ESA-listed corals are present (Figure 8) and designated elkhorn and staghorn coral critical habitat units (Puerto Rico, St. Croix, and St. Thomas/St. John), but very limited Navy activities occur in these locations.

The ESA-listed corals considered in this opinion are most common in water depths of 30 m or less, though corals in the star complex (particularly boulder star and mountainous star) and rough cactus coral have been documented down to 90-m depths. In the U.S. Caribbean, boulder and mountainous star corals are often dominant in depths between 40 to 50 m and common in depths up to 90 m (e.g., in areas between the eastern side of the main island of Puerto Rico and the Virgin Islands, which include Culebra and Vieques Islands).

In areas that do not contain coral reefs or colonized hard bottom, we do not expect an explosion at the water surface to result in impacts to ESA-listed coral colonies. However, an explosion at the water surface on or near the marine bottom in areas containing ESA-listed corals could result in impacts to ESA-listed coral colonies depending upon the depth from the water surface to the coral colonies and the blast radius associated with the explosive. Based on supplemental information provided by the Navy during consultation, no explosive ordnance would be used within the depth range of ESA-listed corals at SFOMF. For this reason, we do not anticipate explosives will impact ESA-listed corals at this location. The explosive ordnance that could be used at KWRC includes buoys, sonobuoys, large and medium caliber projectiles, torpedoes, and missiles. Most explosives proposed have a net explosive weight of less than 0.5 pounds. Many others have a net explosive weight of less than 5 pounds, whereas torpedoes and missiles have a larger net explosive weight. The vast majority of explosives proposed for use at KWRC, including all torpedoes and missiles with the larger net explosive weight, would occur in waters deeper than the depth range of all ESA-listed corals (i.e., > 90 m). Some explosives with less than 0.5 pound net explosive weight could be used in waters less than 60 m, and some explosives with less than 5 pound net explosive weight could be used in waters less than 90 m, but greater than 60 m.

Most marine invertebrates, including ESA-listed coral species, lack air bladders and are therefore considered less vulnerable to damaging effects of pressure waves than some other organisms such as fish with swim bladders (Keevin and Hempen 1997). Mortality rates with distance from explosions have not been determined for coral species, though studies have documented impacts to corals from underwater explosions. For example, based on observations during the use of explosives on Cross Cay, Puerto Rico, corals, including elkhorn coral, were completely broken off near their bases from the pressure wave generated by a series of blasts with maximum net explosive weight of 2,170 pounds (Brown and Smith 1972). The authors noted that most of damage was observed very close to the demolition area, with decreasing damage seaward. They noted that very little damage was observed outside of the mouth of the cove where the blasts occurred, a distance of less than 100 yards away. Based on a number of literature reviews, the limited number of experiments performed to date have not used comparable methods, adequate sample sizes, or adequate controls, and did not typically measure pressure waves associated with the explosion. This makes it difficult to reach conclusions regarding the injurious impacts to invertebrates from sound associated with the use of explosives ((Keevin and Hempen 1997). The Navy made predictions regarding the range of vulnerability for fish with swim bladders, porpoises, and human swimmers and used computer programs based on physical-biological models to calculate vulnerability ranges for other organisms, including crabs, oyster, lobster, shrimp, and flounder (which do not have a swim bladder; Young 1991). These are represented by the curves estimating the distance from an explosion beyond which at least 90 % of shrimp, lobster, oyster, and crabs would survive, depending on the weight of the explosive (Young 1991)

(Figure 52). The Navy used this information to develop mitigation measures including buffers around shallow coral reefs in the absence of range to effects values for corals.

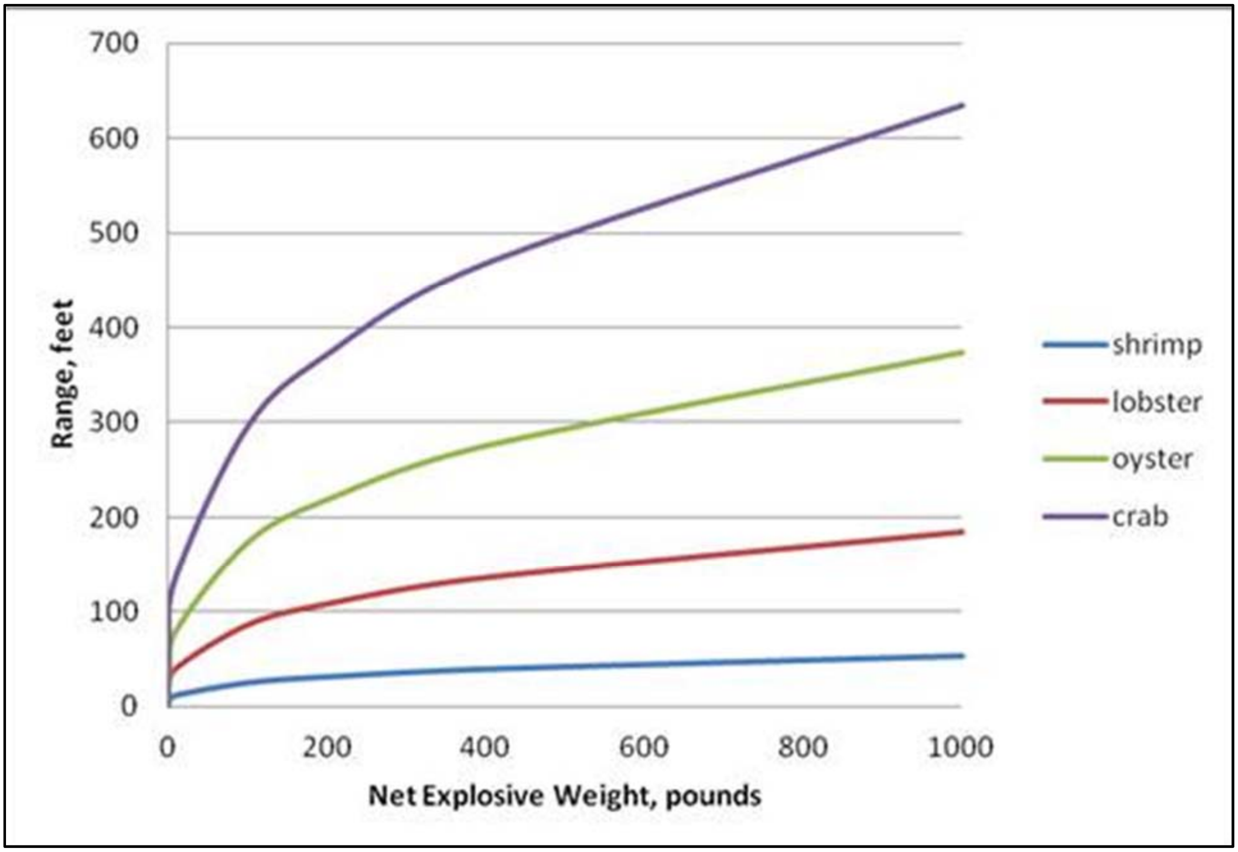


Figure 52. Prediction of distance to 90 percent survivability of marine invertebrates exposed to an underwater explosion (Young 1991).

Based on the information in Figure 52, and to be protective of ESA-listed coral species, we used information on the distance to 90 percent survivability of crabs (i.e., the most susceptible invertebrate) to estimate the range to mortality for ESA-listed corals exposed to the ordnance that could be used within the depth range of ESA-listed corals. The range to 90 percent survivability for large caliber explosives (net explosive weight = < 5 pounds) is approximately 30 m, and the range to 90 percent survivability for medium caliber explosives (i.e., < 0.5 pounds) is much less than 30 m, likely by an order of magnitude based on net explosive weight. Since large caliber explosives are only proposed for use in waters greater than 60 m depth and the range to effect for this ordnance type is approximately 30 m, we do not anticipate this ordnance to impact ESA-listed coral on the seafloor. Similarly, the likelihood of medium caliber projectiles impacting ESA-listed corals on the seafloor is also very low due to the short range to 90 percent survivability, and that per the Navy's mitigation described in Section 3.4.2.2.1, medium caliber gunnery exercises are not conducted within a 350 yard radius of shallow-water coral reefs. For these reasons, it is extremely unlikely that ESA-listed corals will be impacted by surface water or water column explosions.

In addition to surface water explosions occurring in offshore waters, mine warfare, demolition, and a small number of other training events occur in nearshore waters (i.e., <30 m depths) that involve explosives. Charges detonated in shallow water or near the bottom, including explosive munitions disposal charges and some explosions associated with mine warfare, could kill and injure ESA-listed coral on or near the bottom, depending on the species and the distance from the explosion.

The only underwater explosions that would occur on or near the bottom in the KWRC would result from use of 5, 10, and 20-pound charges during mine warfare training and testing activities. Appendix F of the Navy's DEIS indicates 20-pound charges could have a 12.5 m^2 crater footprint from the explosion (Navy 2017c). These activities occur within the depth range of all ESA-listed corals (up to 90 m for some species) and elkhorn and staghorn coral critical habitat (up to 30 m), but in designated locations that have been used for this purpose for decades. According to the Navy, these locations have soft bottom, and corals have never been observed over decades of use of these established training areas (Navy Memorandum for the Record [MFR]; May 3, 2018). Because of the small charges used in these areas, the small crater footprint expected, the expected dominance of soft bottom habitat, and the lack of observation of corals in these areas despite decades of use (including during activities involving divers), it is extremely unlikely that these activities will result in injury or mortality to ESA-listed coral colonies. Reef areas down-current from these explosions could experience minor increases in sedimentation, but we expect these effects to dissipate quickly due to the distance away from the detonation (i.e., at least 350 yards), the small charge sizes, and currents. For this reason, the potential effects of sedimentation from explosives during mine warfare training in shallow water habitats is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Limpet mine training is planned in the waters around Naval Air Station Key West and specifically at Demo Key or within Truman Harbor. A Navy-funded survey of Naval Air Station Key West's explosive training areas found suitable substrate for ESA-listed coral species on the artificial structures lining Truman Harbor and Mole Pier but not in Demo Key (Navy 2017a). The survey of Truman Harbor documented the occurrence of three clusters of ESA-listed mountainous star corals on Mole Pier near the explosive training areas. During limpet mine training, a very small charge (2.2 pounds) is placed in a seafloor device that directs the explosive energy upward in very shallow water, making it unlikely that ESA-listed coral colonies will be affected. Because of the small charge size and the direction of explosive energy upward (i.e., not out across the seafloor), it is extremely unlikely that limpet mine training would impact ESA-listed corals at Demo Key or within Truman Harbor. Therefore the effect of limpet mine training on ESA-listed corals is discountable.

In terms of ESA-listed coral larvae, as noted previously, detonation of explosives where larvae are present could lead to trauma or mortality. The use of explosives during mass spawning of all ESA-listed corals except rough cactus coral (which is a brooder and for which the timing of release of larvae is not known) could affect the settlement of coral larvae, leading to a potential decline in numbers of new recruits. Coral larvae respond to acoustic cues that may facilitate detection of habitat from large distances and from up-current of preferred settlement locations

(Vermeij et al. 2010). Thus, the use of explosives could lead to trauma that affects larvae's ability to respond to these acoustic cues or disrupt the use of these cues due to the noise associated with the explosions. In a project to sample coral larvae during mass spawning events off the coast of Salinas, Puerto Rico, the highest coral larvae density observed was on September 7, 2015, with 6,532 larvae per 26,400 gallons (100 cubic meters) in the nighttime mid-depth tow (FERC 2016). Peak larval densities in the water lasted up to 11 days after the full moon. Therefore, depending on the number of days over which the use of explosives occur, the activities could result in the loss of thousands of coral larvae. Larval survival may be only one percent, meaning that a very small fraction of the larvae that may be affected by the use of explosives would have survived to settle on hard substrate and begin to grow into a coral colony. However, the areas used by the Navy for training and testing activities involving the use of explosives are only a small portion of the range of ESA-listed coral species in the action area. Training and testing activities are not continuous and are not expected to correspond with coral mass spawning events every time they take place. For these reasons, we believe the potential effect to ESA-listed coral larvae and future recruits of ESA-listed coral species resulting from the use of explosives is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

In summary, it is extremely unlikely that Navy explosives will impact ESA-listed coral colonies or coral critical habitat. Therefore, the potential effects of Navy explosives on these resources are discountable. Additionally, the potential effect to ESA-listed coral larvae and future recruits of ESA-listed coral species resulting from the use of explosives is insignificant.

9.1.5.4 Physical Disturbance and Strike Stressors – Corals

The sections below discuss the potential effects of physical disturbance and strike on ESA-listed corals from vessels and seafloor devices.

9.1.5.4.1 Vessels

In the sections below, we discuss the potential for Navy vessel operations to result in adverse impacts to ESA-listed corals and elkhorn and staghorn designated critical habitat in the action area.

Vessel Grounding

Due to the number and size of vessels that will be used in the action area, there is a possibility that vessels may ground in areas containing ESA-listed corals and elkhorn and staghorn coral critical habitat. However, a Navy vessel has never run aground during training and testing activities in the action area within the distribution of ESA-listed corals (Navy MFR; May 3, 2018). Additionally, none of the activities proposed to occur in the action area occur at depths that could potentially result in bottom scouring (J. Nissen, Navy, personal communication to E. MacMillan, NMFS; July 24, 2018). Finally, vessels have GPS systems and charts that enable them to maintain courses in waters with depths that should be adequate for vessel operation. For these reasons, it is extremely unlikely that a Navy vessel will ground in areas containing ESA listed corals or coral critical habitat and the potential effect of vessel grounding is discountable.

Propeller Wash

Propeller wash from vessels operating in areas with unconsolidated sediments could lead to sediment resuspension and transport. Depending on the frequency and duration of the activity resulting in sediment resuspension, the type of sediment (i.e., sand, silt), and the location of the sediment plume in relation to the location of areas containing ESA-listed coral colonies and the essential feature of elkhorn and staghorn coral critical habitat, there could be impacts to these resources. Impacts have the potential to include smothering of colonies or responses to sediment stress such as mucous production and a diversion of energy from processes including sexual reproduction of ESA-listed coral colonies. The essential feature of elkhorn and staghorn coral could suffer a temporary loss of function due to sedimentation. If vessel operation in these areas leads to chronic sediment stress, full or partial mortality of ESA-listed coral colonies, and the loss of the essential feature of coral critical habitat from areas that are frequently covered by sediment, could occur.

However, most Navy training and testing activities in the action area that occur within the distribution of ESA-listed coral and coral critical habitat occur in water deep enough to avoid sediment resuspension. Per correspondence with the Navy during this consultation, SFOMF is the only location where Navy activities using vessels take place in relatively shallow waters where ESA-listed corals are known to occur (Navy MFR; May 3, 2018). In this location, vessels typically would be transiting through shallow water areas while in route to more offshore locations where the majority of training and testing activities are conducted. One of the mitigation measures proposed by the Navy in this area is to operate in waters with at least a one-foot clearance between the deepest draft of the vessel (with the motor down) and the seafloor at mean low water. [23] While this mitigation is likely to reduce the likelihood of sediment resuspension, a one-foot clearance may not be adequate in all cases to avoid propeller wash as vessels navigate over areas with unconsolidated sediments. However, increases in turbidity caused by resuspension of sediment would be expected to quickly subside (i.e., within hours) after the vessel transits through the area of shallow water to more offshore, deeper water locations. Any sediments that do not immediately settle to the seafloor are expected to be swept away in currents and/or tidal flow and diluted to undetectable levels. In summary, while we anticipate Navy vessels to result in some sediment resuspension in areas where ESA-listed corals occur, due to the infrequent and temporary nature of any sediment resuspension, impacts would

[23] This measure is not applicable to training and testing locations beyond the SFOMF due to the relatively deeper water depths where vessels are used in these other areas. Scouring and prop dredging from vessel movements are not expected to occur due to the Navy's standard collision avoidance procedures to prevent damage to equipment and the resulting safety risks for vessel personnel (Navy MFR; May 3, 2018).

be insignificant to ESA-listed corals (i.e., so minor that the effect cannot be meaningfully evaluated).

Anchoring

Anchoring of vessels has the potential to impact ESA-listed corals and elkhorn and staghorn coral critical habitat through breakage and structural damage from the weighing of anchors in areas containing corals and their habitat. Anchor lines and tackle of mooring buoys could also lead to damage to ESA-listed coral colonies associated with scour as the lines or chains move around on the seafloor with the swing of the vessel on the anchor or mooring or as a mooring buoy moves around its anchor. The Navy's BA states that precision anchoring could occur in the action area. However, per correspondence with the Navy during this consultation, the Navy informed NMFS that precision anchoring will not occur in areas where ESA-listed corals occur (Navy MFR; May 3, 2018). During testing activities at SFOMF, vessels may need to anchor, though this is not a part of standard operations at this location (B. Colbert, Navy, personal communication to E. MacMillan, NMFS; May 7, 2018). If anchoring is required, Navy personnel will conduct surveys of the location where the anchor will be dropped. If corals are observed within the potential anchor drop area or within the swing of the anchor chain, a different location will be selected (B. Colbert, Navy, personal communication to E. MacMillan, NMFS; May 7, 2018). Alternatively, the Navy may use already established moorings.[24] When established moorings are used, anchors and tackle from testing vessels will not make contact with the seafloor (B. Colbert, Navy, personal communication to E. MacMillan, NMFS; May 7, 2018). For the reasons described above, it is extremely unlikely that a Navy vessel operations involving anchoring will impact ESA-listed corals and the potential effect of anchoring on ESA-listed corals is discountable.

Seawater Intake

The intake of seawater by vessels and cavitation in propellers could also lead to trauma or mortality of ESA-listed coral larvae. The use of vessels during mass spawning of all ESA-listed corals except rough cactus coral (which is a brooder and for which the timing of release of larvae is not known) could affect the settlement of coral larvae, leading to a potential decline in numbers of new recruits. In a project to sample coral larvae during mass spawning events off the coast of Salinas, Puerto Rico, the highest coral larvae density observed was on September 7, 2015, with 6,532 larvae per 26,400 gallons (100 cubic meters) in the nighttime mid-depth tow (FERC 2016). Peak larval densities in the water lasted up to 11 days after the full moon. Therefore, depending on when vessels are used and for how long, vessel operation could result in some loss of individual coral larvae. Larval survival in normal conditions may be only one

[24] The establishment of the mooring sites is not part of the proposed action and is not being considered in this consultation.

percent, meaning that a very small fraction of the larvae that may be affected by the use of vessels would have survived to settle on hard substrate and begin to grow into a coral colony. The areas used by the Navy for training and testing activities involving the use of vessels are only a small portion of the range of ESA-listed coral species in the action area and activities generally avoid areas where corals occur. Training and testing activities are not continuous and are not generally expected to correspond with coral mass spawning events. For these reasons, we believe the potential effect to ESA-listed coral larvae and future recruits of ESA-listed coral species resulting from the use of vessels is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.5.4.2 Seafloor Devices

Seafloor devices include items that are placed on, dropped on, or moved along the seafloor and include mine shapes, anchor blocks, anchors, and bottom-placed instruments.[25]

In SFOMF, though a number of seafloor devices are used, the vast majority would be used in waters deeper than ESA-listed corals occur (i.e., at depths > 90 m) (Navy MFR; July 7, 2018). The only seafloor devices that would be used in this location within the depth range of ESA-listed corals are anchors and mine shapes associated with unmanned underwater vehicle testing. However, the Navy does not deploy these devices without viewing the bottom via a diver or remotely operated vehicle. Per the mitigation proposed by the Navy to avoid impacting seafloor resources (Table 39), the Navy will not place anchors or mine shapes within 350 yards of shallow water coral reefs or live hard bottom. Because of this mitigation measure and that the Navy will view the bottom prior to placing seafloor devices in this area, it is extremely unlikely that a seafloor device will be placed on ESA-listed corals at the SFOMF.

The other location in the action area where seafloor devices are used that overlaps with the distribution of ESA-listed corals is the KWRC. In this area, seafloor devices are used during three types of activities: mine neutralization/explosive ordnance disposal; underwater construction team training; and underwater mine countermeasure raise, tow, beach, and exploitation operations. Mine neutralization/explosive ordnance disposal will be conducted at depths greater than 90 m (i.e., deeper than the depth distribution of ESA-listed corals and coral critical habitat). Because this activity is conducted in waters deeper than the known depth distribution of ESA-listed corals, it is extremely unlikely that seafloor devices from mine neutralization/explosive ordnance disposal activities at will impact ESA-listed corals.

The other two activities that use seafloor devices in the KWRC could occur in waters within the depth range of ESA-listed corals and coral critical habitat. However, as explained further below, due to the Navy's mitigation, as well as standard operating procedures to ensure successful

[25] Unmanned underwater vehicles will be used in the SFOMF, but these vehicles do not operate along the seafloor (Benjamin Colbert, Navy, personal communication to Eric MacMillan, NMFS; May 7, 2018).

training and testing, the likelihood of seafloor devices resulting in impacts to ESA-listed corals or coral critical habitat is extremely low.

For underwater construction team training, the seafloor devices used are bottom placed instruments. For underwater mine countermeasure raise, tow, beach, and exploitation operations, the seafloor devices used are mine shapes. Per the mitigation proposed by the Navy to avoid impacting seafloor resources (Table 39), the Navy will not place either of these devices on the seafloor within 350 yards of shallow water coral reefs or live hard bottom. As shown in Figure 53, there is a large amount of area in the KWRC with suitable soft substrate where these items can be placed where it would not be anticipated that ESA-listed corals or coral critical habitat would occur. Further, for underwater construction team training, materials are typically diver placed. For underwater mine countermeasure raise, tow, beach, and exploitation operations, mine shapes can be diver placed, but not always. This activity is typically conducted in repeat areas, and if not, then available information on substrate type (i.e., either available mapping data or additional survey effort) is used to identify a suitable location away from coral reefs or live hard bottom (J. Nissen, Navy, personal communication to E. MacMillan, NMFS; July 24, 2018).

Because of the Navy's proposed mitigation for seafloor resources, that most seafloor devices are diver placed, and the availability of mapping to identify areas of soft bottom habitat where ESA-listed corals would not be expected to occur, it is extremely unlikely that a seafloor devices used in KWRC will be placed on ESA-listed corals or coral critical habitat and the potential effect of this stressor on these resources is discountable.

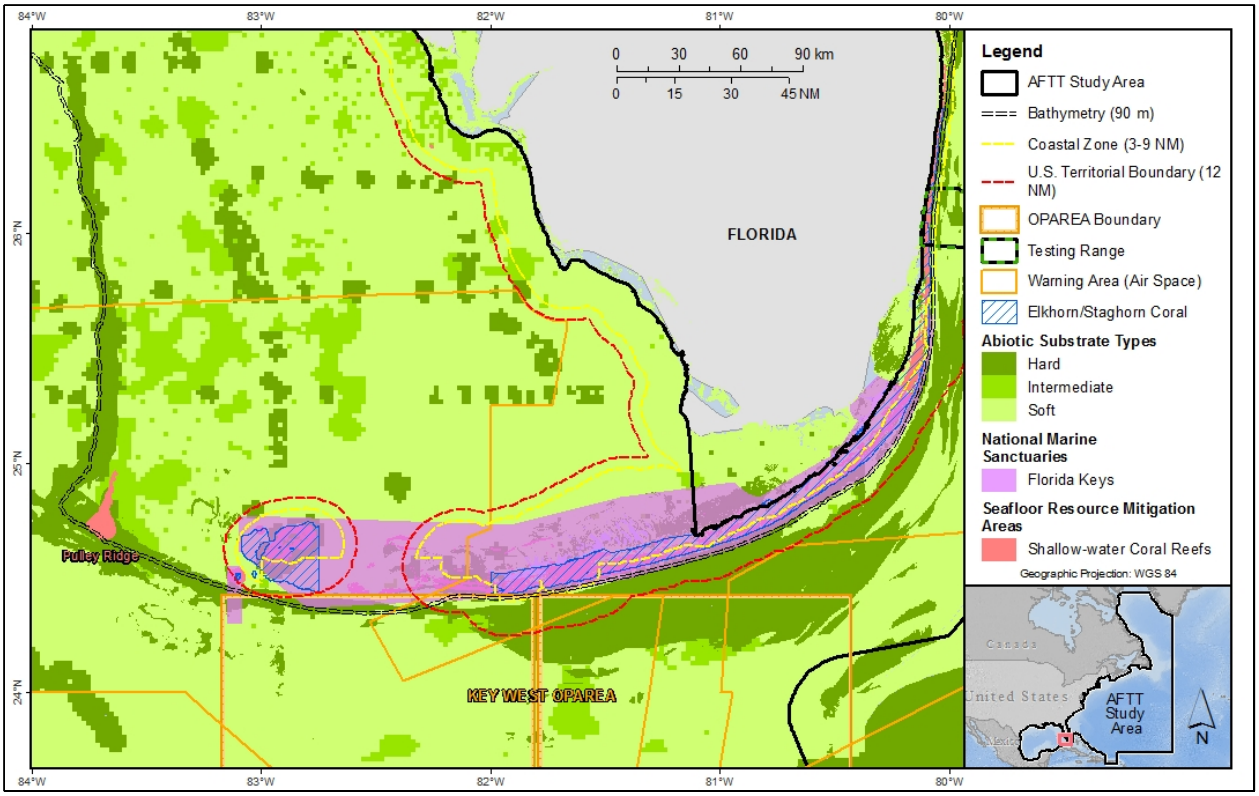


Figure 53. The distribution of known shallow-water coral reefs and hard substrate suitable for other shallow-water coral reef species (<90 meters deep) in the Key West Range Complex.

9.1.5.5 Ingestions Stressors – Corals

As described previously (Section 6), military expended materials will be generated from training and testing activities. Some expended material is composed of plastic which, if left unrecovered, would degrade over time, and become small particles (particles less than 5 millimeters called microplastics). Recent studies indicate that the health of several coral species are negatively affected by microplastics, with laboratory studies showing bleaching and tissue necrosis associated with mucus production to try and remove these materials from their surface, feeding interactions, and overgrowth of materials on their surface (e.g., Reichert et al. 2018). Thus, the generation of large quantities of unrecovered plastic debris as a result of training and testing activities has the potential to impact the health of ESA-listed corals. However, relative to the amount of plastic debris in the ocean, the Navy contributes an extremely small amount. It's been estimated that approximately 10 percent of all plastics produced end up in the marine environment, where they persist and degrade (Cole et al. 2011). In 2009, 230 million tons of plastic was produced worldwide (PlasticsEurope 2010; as cited in Cole et al. 2011). Andrady (2011a) found that most (~ 80 percent) plastic in the ocean environment is from terrestrial sources. Other documented sources include coastal tourism, recreational and commercial fishing, and marine industries (e.g., oil and gas). Additionally, it is worth noting that except for plastic discharged during training and testing activities, U.S. Navy vessels have a zero-plastic trash discharge policy and return all plastic waste to appropriate disposal sites on shore.

While the Navy expends some materials which contain plastic in the action area, relative to the total amount of plastic debris in the ocean, the Navy contribution is insignificant. Though it is possible for some plastic of military origin to degrade over time and become small particles that could be consumed by ESA-listed corals, the likelihood that plastic debris generated by Navy activities degrades and is ingested by ESA-listed corals in a sufficient quantity to result in adverse impacts is extremely low. For this reason, the effect of ESA-listed coral ingestion of microplastics of Navy origin is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.5.6 Secondary Stressors (Munitions Constituents) – Corals

Munitions constituents from expended munitions items and unexploded ordnance have the potential to affect ESA-listed coral colonies if items remain on the seafloor on or adjacent to these colonies. A study by Porter et al. (2011) at Vieques, Puerto Rico, a former Navy bombing range that was heavily used, found an inverse relationship between the density of ordnance and coral reef health, as well as concentrations of munitions constituents, particularly explosive-type compounds, in coral tissue that exceed concentrations in mobile organisms like fish. This is in contrast to the findings of Smith and Marx Jr. (2016), who conducted surveys at a Navy bombing range in the Mariana Archipelago in the Pacific Ocean and found no overall long-term adverse impacts to corals or other invertebrates due to expended items, despite several decades of use and observations of intact bombs and fragments on the bottom. Inert 500-pound bombs were found to disturb a bottom area of 17 m^2 each, although specific damage to invertebrates was not described. Expended inert items, once settled in place, became encrusted with marine growth and appeared to pose no substantial long-term threat to invertebrates. The condition of corals indicated a healthy environment, with no apparent change in species composition, distribution, size, or stress indicators. Each of these examples are from locations that were or are heavily used Navy bombing ranges with a large amount of ordnance expended in a relatively small area. An analysis of sediments near munitions items in Ordnance Reef, Hawai'i observed that all of the contaminated sediments that contained an explosive-type constituent were found immediately adjacent to a munitions item, indicating there was no widespread contamination due to the presence of the munitions items. Similarly, an examination of available data completed by Lotufo et al. (2017) indicates that concentrations of munitions constituents in water and sediment were largely below detection limits with higher concentrations being very localized near a point source (i.e., the munitions item).

The research above indicates that in most cases, sediment contamination from munitions constituents would not result in impacts to invertebrates on the seafloor (e.g., Smith and Marx 2016) except in specific cases. The only situation where significant effects to invertebrates have been observed was at a heavily used bombing range in Puerto Rico. The munitions use from the proposed action within the range of ESA-listed corals is infrequent, occurs over a large action area (i.e., thousands of kilometers), and mostly occurs in waters beyond the depth distribution of ESA-listed corals. Munitions use as part of the proposed action is not similar to that which occurred at Vieques. For these reasons, it is extremely unlikely that munitions constituents will result in adverse impacts to ESA-listed corals from the proposed action. Therefore, the effect of this stressor on ESA-listed corals is discountable.

9.2 Stressors Likely to Adversely Affect ESA-listed Resources

We determined that the following stressors associated with the proposed action are likely to adversely affect ESA-listed resources:

1) Acoustic stressors from sonar and other transducers – Marine mammals and sea turtles;
2) Acoustic stressors from air guns – Sea turtles
3) Acoustic stressors from pile driving – Sea turtles and fishes
4) Explosive stressors in water – Marine mammals, sea turtles, and fishes;
5) Physical disturbance and strike stressors from vessels – marine mammals, sea turtles, and fishes;
6) Physical disturbance and strike stressors from military expended materials – corals, elkhorn and staghorn coral critical habitat;
7) Entanglement stressors from military expended materials – Corals, elkhorn and staghorn coral critical habitat.

The following sections describe the effects of these stressors on ESA-listed resources. First, we describe the potential adverse effects of the stressor, then we summarize the exposure analysis which estimated the number of individuals of each ESA-listed species that may be exposed to the stressor (where possible). Next, we provide our assessment of the likely responses these species will exhibit to this exposure. Finally, in our risk analysis, we assess the likely consequences of the responses to the individuals that have been exposed.

Additionally, as described previously in Section 3.2.7, while NMFS recognizes that Navy training and testing requirements change over time in response to global or geopolitical events and other factors, the general types of activities addressed by this consultation are expected to continue into the reasonably foreseeable future, along with the associated impacts. Therefore, as part of our effects analysis, we assumed that the training and testing activities proposed by the Navy during the period of NMFS' proposed incidental take authorization pursuant to the MMPA would continue into the reasonably foreseeable future at levels similar to those assessed in this opinion. Note that while the analysis assumes Navy activities, along with the associated impacts, will continue into the reasonably foreseeable future, the reinitiation triggers described in Section 15 apply such that if any of the following criteria are met, reinitiation of formal consultation is required:

(1) The amount or extent of taking specified in the ITS is exceeded.
(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
(3) The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.
(4) A new species is listed, or critical habitat designated under the ESA that may be affected by the action.

9.2.1 Marine Mammals

This section discusses the effects of acoustic (i.e., from sonar and other transducers), explosive, and vessel strike stressors on ESA-listed marine mammals.

9.2.1.1 Sonar and Other Transducers – Marine Mammals

As described further in Section 6.1.3, sonar and other transducers includes a variety of acoustic devices used to obtain and transmit information about the undersea environment. Some examples are mid-frequency hull-mounted sonars used to find and track submarines; high-frequency small object detection sonars used to detect mines; high-frequency underwater modems used to transfer data over short ranges; and extremely high-frequency (> 200 kHz) Doppler sonars used for navigation, like those used on commercial and private vessels.

9.2.1.1.1 Potential Effects of Sonar and Other Transducers for Marine Mammals

Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sources, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging, there are many unknowns in assessing impacts such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007a). Furthermore, many other factors besides the received level of sound may affect an animal’s reaction such as the duration of the sound-producing activity, the animal’s physical condition, prior experience with the sound, activity at the time of exposure (e.g., feeding, traveling, resting), the context of the exposure (e.g., in a semi-enclosed bay vs open ocean), and proximity to the source of the sound.

The potential effects of acoustic exposure range from physical injury or trauma, to an observable behavioral response, to a stress response that may not be detectable. Injury can occur to organs or tissues of an animal. Hearing loss is a noise-induced decrease in hearing sensitivity, which can either be temporary or permanent. Stress can help an animal cope with changing conditions, but too much stress can result in negative physiological effects. Masking can occur when the perception of a biologically-important sound is interfered with by a second sound (e.g., noise from Navy training and testing). Behavioral responses range from brief distractions to avoidance of a sound source to prolonged flight. The sections below provide additional background on the potential effects of sonar and other transducers on marine mammals. In the exposure, response, and risk analyses below (i.e., Sections 9.2.1.1.2, 9.2.1.1.3, and 9.2.1.1.4, respectively), we use this information to discuss the likely effects of Navy sonar use on ESA-listed marine mammals.

9.2.1.1.1.1 Injury

Injury (i.e., physical trauma) refers to the effects on the tissues or organs of an animal due to exposure to pressure waves. The potential for injury due to exposure to non-explosive acoustic stressors such as active sonar that is proposed for use in the action area is discussed below.

Nitrogen decompression

Marine mammals are thought to deal with nitrogen loads in their blood and other tissues, caused by gas exchange from the lungs under conditions of high ambient pressure during diving, through anatomical, behavioral, and physiological adaptations (Hooker et al. 2012). Although not a direct injury, variations in marine mammal diving behavior or avoidance responses could result in nitrogen off-gassing in super-saturated tissues, possibly to the point of deleterious vascular and tissue bubble formation (Hooker et al. 2012; Jepson et al. 2003; Saunders et al. 2008) with resulting symptoms similar to decompression sickness (also known as “the bends” in humans). The process has been under debate in the scientific community (Hooker et al. 2012; Saunders et al. 2008), although analyses of by-caught and drowned animals has demonstrated that nitrogen bubble formation can occur once animals are brought to the surface and tissues are supersaturated with nitrogen (Bernaldo De Quiros et al. 2013; Moore et al. 2009b). Deep diving whales, such as beaked whales (not listed under the ESA), normally have higher nitrogen loads in body tissues, which may make them more susceptible to decompression for certain modeled changes in dive behavior (Fahlman et al. 2014b; Fernandez et al. 2005a; Hooker et al. 2012; Jepson et al. 2003).

Researchers have examined how dive behavior affects tissue supersaturation conditions that could put an animal at risk of gas bubble embolism. An early hypothesis was that if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Fernández et al., 2005; Jepson et al., 2003). However, modeling suggested that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer and Tyack 2007). Instead, emboli observed in animals exposed to mid-frequency active sonar (Fernandez et al. 2005a; Jepson et al. 2003) could stem from a behavioral response that involves repeated dives, shallower than the depth of lung collapse (Hooker et al. 2012; Tyack et al. 2006; Zimmer and Tyack 2007). Longer times spent diving at mid-depths above lung collapse would allow gas exchange from the lungs to continue under high hydrostatic pressure conditions, increasing potential for supersaturation; below the depth of lung collapse, gas exchange from the lungs to the blood would likely not occur (Fahlman et al. 2014b). However, Costidis and Rommel (2016) suggest that gas exchange may continue to occur across the tissues of air-filled sinuses in deep-diving odontocetes below the depth of lung collapse, if hydrostatic pressures are high enough to drive gas exchange across into non-capillary veins, contributing to tissue gas loads. To examine the potential for gas bubble formation, a bottlenose dolphin was trained to dive repetitively to depths shallower than lung collapse to elevate nitrogen saturation to the point that asymptomatic nitrogen bubble formation was predicted to occur. However, inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of any nitrogen gas bubbles (Houser et al. 2009). To estimate risk of decompression sickness, Kvadsheim (2012) modeled gas exchange in the tissues of sperm, pilot, killer, and beaked whales based on actual dive behavior during exposure to sonar in the wild. Results indicated that venous supersaturation was within the normal range for these species, which have naturally high levels of nitrogen loading. Researchers have also considered the role of accumulation of carbon dioxide produced during periods of high activity by an animal, theorizing that accumulating carbon dioxide, which cannot be removed by gas exchange below the depth of lung collapse, may facilitate the formation of bubbles in nitrogen saturated tissues (Bernaldo De Quiros et al. 2012; Fahlman et al. 2014b).

Modeling has suggested that the long, deep dives performed regularly by beaked whales over a lifetime could result in the saturation of long-halftime tissues (i.e., tissues that take longer to give off nitrogen, e.g., fat and bone lipid) to the point that they are supersaturated when the animals are at the surface (Fahlman et al. 2014b; Hooker et al. 2009; Saunders et al. 2008). The presence of osteonecrosis (bone death due to reduced blood flow) in deep diving sperm whales has been offered as evidence of chronic supersaturation (Moore and Early 2004). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al. 2006; Hooker et al. 2009), while the condition of supersaturation required for bubble formation in these tissues has been demonstrated in marine mammals drowned at depth as fisheries bycatch and brought to the surface (Moore et al. 2009b). For beaked whale strandings associated with sonar use, one theory is that observed bubble formation may be caused by long periods of compromised blood flow caused by the stranding itself (which reduces ability to remove nitrogen from tissues) following rapid ascent dive behavior that does not allow for typical management of nitrogen in supersaturated, long-halftime tissues (Houser et al. 2009).

A fat embolic syndrome (out of place fat particles, typically in the bloodstream) was identified by Fernandez et al. (2005b) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals and was thought to possibly arise from the formation of bubbles in fat bodies, which subsequently resulted in the release of fat emboli into the blood stream.

Dennison et al. (2011) reported on investigations of dolphins stranded in 2009 to 2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of the 22 live-stranded dolphins and in the liver of two of the 22. The authors postulated that stranded animals are unable to recompress by diving, and thus may retain bubbles that are otherwise re-absorbed in animals that can continue to dive. The researchers concluded that the minor bubble formation observed could be tolerated since the majority of stranded dolphins released did not re-strand.

The appearance of extensive bubble and fat emboli in beaked whales (not listed under the ESA) is unique to strandings associated with certain high intensity sonar events. The phenomenon has not been observed in other stranded marine mammals, including beaked whale strandings not associated with sonar use. It is not clear whether there is some mechanism for this phenomenon specific to beaked whales or whether the phenomenon occurs only following rapidly occurring stranding events (i.e., when whales are not capable of sufficiently decompressing). Because of the lack of evidence for extensive nitrogen bubble formation while diving, NMFS believes that the probability of ESA-listed marine mammals getting "the bends" following acoustic exposure to be so low as to be extremely unlikely and thus discountable.

Acoustically-induced bubble formation due to sonars

A suggested cause of injury to marine mammals is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a microscopic gas bubble by exposing it to a sound field. The process is dependent upon a number of factors including the sound pressure level and duration. Under this hypothesis, microscopic bubbles assumed to exist in the tissues of marine mammals may experience one of three things: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs, (2) bubbles develop to the extent that an immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lungs without negative consequence to the animal.

Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. As discussed above, repetitive diving by marine mammals can cause the blood and some tissues to become supersaturated (Ridgway and Howard 1979). The dive patterns of some marine mammals (e.g., non-ESA listed beaked whales) are predicted to induce greater supersaturation (Houser et al. 2001). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness.

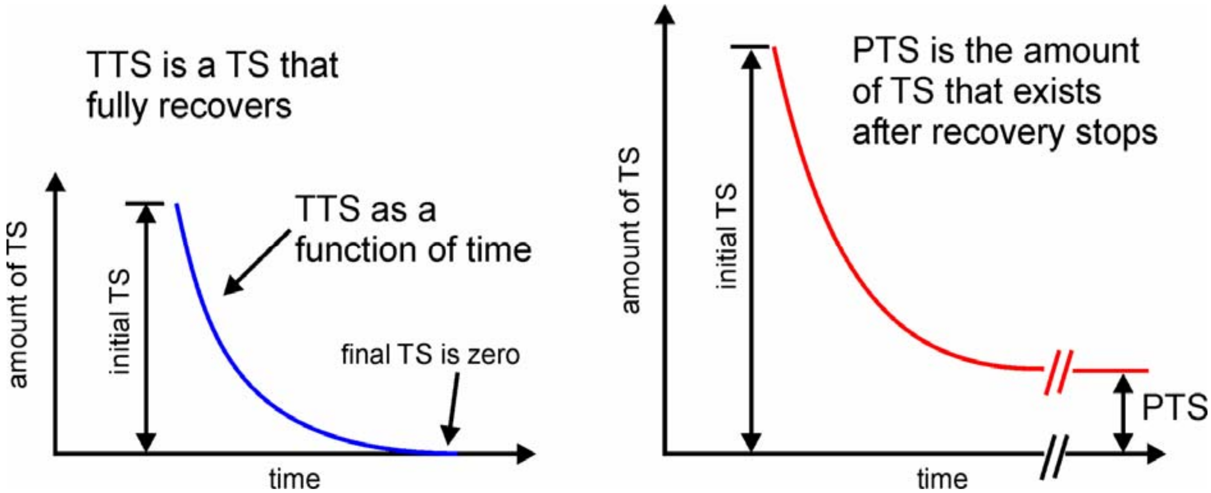
It is unlikely that the short duration of sonar pulses would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested, which is that stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of supersaturated tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough time for bubbles to reach a problematic size. The phenomena of bubble growth due to a destabilizing exposure was shown by Crum et al. (2005)

by exposing highly supersaturated ex vivo bovine tissues to a 37 kHz source at 214 dB re 1 μPa. Although bubble growth occurred under the extreme conditions created for the study, these conditions would not exist in the wild because the levels of tissue supersaturation in the study (as high as 400–700 percent) are substantially higher than model predictions for marine mammals (Fahlman et al. 2009; Fahlman et al. 2014b; Houser et al. 2001; Saunders et al. 2008). In addition, such high exposure levels would only occur in very close proximity to the most powerful sonars. It is improbable that this mechanism is responsible for stranding events or traumas associated with beaked whale strandings. For these reasons, NMFS believes that the probability of ESA-listed marine mammals being injured from acoustically induced bubble formation to be extremely low, and thus, discountable.

9.2.1.1.1.2 Hearing Loss and Auditory Injury

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

Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative. Hearing loss is typically quantified in terms of threshold shift (TS) — the amount (in dB) that hearing thresholds at one or more specified frequencies are elevated, compared to their pre-exposure values, at some specific time after the noise exposure. The amount of TS measured usually decreases with increasing recovery time — the amount of time that has elapsed since a noise exposure. If the TS eventually returns to zero (i.e., the hearing threshold returns to the pre-exposure value), the threshold shift is called a temporary threshold shift (TTS). If the TS does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining TS is called a permanent threshold shift (PTS). Figure 54 shows two hypothetical TSs: one that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. By definition, TTS is a function of the recovery time, therefore comparing the severity of noise exposures based on the amount of induced TTS can only be done if the recovery times are also taken into account. For example, a 20-dB TTS measured 24 hours post-exposure indicates a more hazardous exposure than one producing 20 dB of TTS measured only 2 minutes after exposure; if the TTS is 20 dB after 24 hours, the TTS measured after 2 minutes would have likely been much higher. Conversely, if 20 dB of TTS was measured after 2 minutes, the TTS measured after 24 hours would likely be much smaller.



Note: TTS is temporary threshold shift; PTS is permanent threshold shift.

Figure 54. Two hypothetical threshold shifts.

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

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

A variety of human and terrestrial mammal data indicate that threshold shifts up to 40 to 50 dB may be induced without PTS and that 40 dB is a precautionary upper limit for allowable threshold shift to prevent PTS (e.g., Kryter et al. 1965; Ward 1960). It is reasonable to assume the same relationship would hold for marine mammals because there are many similarities between the inner ears of marine and terrestrial mammals. Experiments with marine mammals have revealed similarities to terrestrial mammals for features such as TTS, age-related hearing loss, drug-induced hearing loss, masking, and frequency selectivity (Finneran et al. 2005; Finneran et al. 2015; Ketten 2000). Therefore, we assume that sound exposures sufficient to produce 40 dB of TTS measured approximately 4 minutes after exposure represent the limit of a non-injurious exposure; i.e., higher level exposures have the potential to cause auditory injury. Exposures sufficient to produce a TTS of 40 dB, measured approximately 4 minutes after exposure therefore represent the threshold for auditory injury. The predicted injury could consist of either hair cell damage/loss resulting in PTS, or other auditory injury such as the delayed neural degeneration identified by Liberman and C. (2009) and Lin et al. (2011b) that may not result in PTS.

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

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

is relatively simple, more accurate than SPL alone, and lends itself easily to scenarios involving multiple exposures with different SPL.

- The amount of TTS depends on the exposure frequency. Sounds at low frequencies, well below the region of best sensitivity, are less hazardous than those at higher frequencies, near the region of best sensitivity (Finneran and Schlundt 2013). The onset of TTS — defined as the exposure level necessary to produce 6 dB of TTS (i.e., clearly above the typical variation in threshold measurements) — also varies with exposure frequency. At low frequencies onset-TTS exposure levels are higher compared to those in the region of best sensitivity.
- TTS can accumulate across multiple exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same SEL (Finneran et al. 2010; Kastelein et al. 2015c; Kastelein et al. 2014b; Mooney et al. 2009b). This means that TTS predictions based on the total, cumulative SEL will overestimate the amount of TTS from intermittent exposures such as sonars and impulsive sources.
- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic (i.e., increasing exposure does not always increase TTS). The time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts recovery may be complete in a few minutes, while large shifts (e.g., approximately 40 dB) may require several days or longer for recovery. Under many circumstances TTS recovers linearly with the logarithm of time (Dear et al. 2010; Finneran et al. 2010; Finneran and Schlundt 2013; Kastelein et al. 2013; Kastelein et al. 2012a; Kastelein et al. 2012b; Kastelein et al. 2014b; Kastelein et al. 2014c; Popov et al. 2014; Popov et al. 2013; Popov et al. 2011). This means that for each doubling of recovery time, the amount of TTS will decrease by the same amount (e.g., 6 dB recovery per doubling of time).

Due to the higher exposure levels or longer exposure durations required to induce hearing loss, only a few types of man-made sound sources have the potential to cause a threshold shift to a marine mammal in the wild. These include some sonars and other transducers used by the Navy and impulsive sound sources such as air guns and impact pile driving that are also used by the Navy.

TTS in mid-frequency cetaceans exposed to non-impulsive sound (e.g., active sonar) has been investigated in multiple studies (e.g., Finneran et al. 2010; Finneran et al. 2005; Finneran and Schlundt 2013; Mooney et al. 2009a; Mooney et al. 2009b) from two species, bottlenose dolphins (*Tursiops truncates*) and beluga whales (*Delphinapterus leucas*). Two high-frequency cetacean species have been studied for TTS due to non-impulsive sources: the harbor porpoise (Kastelein et al. 2012b) and the finless porpoise (*Neophocaena phocaenoides*) (Popov et al. 2011). TTS from non-impulsive sounds has also been investigated in three pinniped species: harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*), and Northern elephant seal (*Mirounga angustirostris*) (e.g., Kastak et al. 2005). These data are reviewed in detail in Finneran (2015).

9.2.1.1.1.3 Physiological Stress

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

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to disease and naturally occurring toxins, lack of prey availability, and interactions with predators all contribute to the stress a marine mammal experiences (Atkinson et al. 2015). Breeding cycles, periods of fasting, social interactions with members of the same species, and molting (for pinnipeds) are also stressors, although they are natural components of an animal's life history. Anthropogenic activities have the potential to provide additional stressors beyond those that occur naturally (Fair et al. 2014; Meissner et al. 2015; Rolland et al. 2012). Anthropogenic stressors potentially include such things as fishery interactions, pollution, and ocean noise. Rolland et al. (2017) studied glucocorticoid hormones in North Atlantic right whales, evaluating healthy whales, those that had been struck by vessels, and those chronically entangled in fishing gear. The authors found that stress hormones in the entangled whales were elevated compared to those of healthy whales and those struck by vessels. The authors also cited several studies to conclude that stress responses over a short period of time (i.e., hours/days) can be beneficial and life-saving. However, chronic elevations of gluticosteroids (i.e., weeks/months) may result in decreased growth, depressed immune system function, and suppression of reproduction (e.g., Romero and Wikelski 2001; Sapolsky et al. 2000).

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

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

Relatively little information exists on the linkage between anthropogenic sound exposure and stress in marine mammals, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). Most studies to date have focused on acute responses to sound either by measuring catecholamines or by measuring heart rate as an assumed proxy for an acute stress response. Belugas demonstrated no catecholamine response to the playback of oil drilling sounds (Thomas et al. 1990) but showed a small but statistically significant increase in catecholamines following exposure to impulsive sounds produced from a seismic water gun (Romano et al. 2004). A bottlenose dolphin exposed to the same seismic water gun signals did not demonstrate a catecholamine response, but did demonstrate a statistically significant elevation in aldosterone (Romano et al., 2004), albeit the increase was within the normal daily variation observed in this species (St. Aubin et al. 1996). Increases in heart rate were observed in bottlenose dolphins to which known calls of other dolphins were played, although no increase in heart rate was observed when background tank noise was played back (Miksis et al. 2001). Unfortunately, it cannot be determined from this study whether the increase in heart rate was due to stress or an anticipation of being reunited with the dolphin to which the vocalization belonged. Similarly, a young beluga's heart rate was observed to increase during exposure to noise, with increases dependent upon the frequency band of noise and duration of exposure, and with a sharp decrease to normal or below normal levels upon cessation of the exposure (Lyamin et al. 2011). However, this response may have been in part due to the conditions during testing. Kvadsheim et al. (2010) measured the heart rate of captive hooded seals during exposure to sonar signals, and found an increase in the heart rate of the seals during exposure periods versus control periods when the animals were at the surface. When the animals dove, the normal dive-related bradycardia (decrease in heart rate) was not impacted by the sonar exposure. Similarly, Thompson et al. (1998; cited in Gordon et al., 2003) observed a rapid but short-lived decrease in heart rates in harbor and gray seals exposed to seismic air guns. Williams et al. (2017b) found a non-linear increase in oxygen consumption with both stroke rate and heart rate in swimming and diving bottlenose dolphins, and found that the average energy expended per stroke increased from 2.81 Joules/kilogram/stroke during preferred swim speeds to a maximum expenditure of 6.41 Joules/kilogram/stroke when freely following a boat.

Similarly, a limited amount of work has addressed how chronic exposure to acoustic stressors affect stress hormones in marine mammals, particularly as it relates to survival or reproduction. In what is probably the only study of chronic noise exposure in marine mammals associating changes in a stress hormone with changes in anthropogenic noise, Rolland et al. (2012) compared the levels of cortisol metabolites in North Atlantic right whale feces collected before and after September 11, 2001. Following the events of September 11, shipping was significantly reduced in the region where fecal collections were made, and regional ocean background noise declined. Fecal cortisol metabolites significantly decreased during the period of reduced ship traffic and ocean noise (Rolland et al. 2012). Considerably more work has been conducted in an attempt to determine the potential effect of boating on smaller cetaceans, particularly killer whales (e.g., Bain 2002; Erbe 2002; Noren et al. 2009). Most of these efforts focused primarily on estimates of metabolic costs associated with altered behavior or inferred consequences of boat presence and noise, but did not directly measure stress hormones. However, Ayres et al. (2012) investigated southern resident killer whale fecal thyroid hormone and cortisol metabolites to assess two potential threats to the species recovery: lack of prey (salmon) and impacts from exposure to the physical presence of vessel traffic (but without measuring vessel traffic noise). Ayres et al. (2012) concluded from these stress hormone measurements that the lack of prey overshadowed any population-level physiological impacts on southern resident killer whales due to vessel traffic. Collectively, these studies indicate the difficulty in teasing out factors that are dominant in exerting influence on the secretion of stress hormones, including the separate and additive effects of vessel presence and vessel noise. The work of Rolland et al. (2012) represents the most provocative link between ocean noise and cortisol in cetaceans to date.

9.2.1.1.1.4 Masking

Masking occurs when one sound, distinguished as the "noise," interferes with the detection or recognition of another sound. The quantitative definition of masking is the amount in decibels an auditory detection or discrimination threshold is raised in the presence of a masker (Erbe et al. 2015). Masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking can lead to vocal changes (e.g., Lombard effect, increasing amplitude, or changing frequency, cessation of vocalization) and behavior changes (e.g., cessation of foraging, leaving an area) on the part of both signalers and receivers, in an attempt to compensate for noise levels (Erbe et al. 2015).

Clark et al. (2009a) developed a method for estimating masking effects on communication signals for low-frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that a right whale's optimal communication space (around 20 km) is decreased by 84 percent when two commercial ships pass through it. Similarly, Aguilar Soto et al. (2006) found that a 15 dB increase in background noise due to vessels led to a communication range of only 18 percent of its normal value for foraging beaked whales. Their method relies on empirical data on source levels of calls (which is unknown for many species) and requires many assumptions such as pre-industrial ambient noise conditions and simplifications of animal hearing and behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Erbe (2015) developed a model with a noise source-centered view of masking to examine how a call may be masked from a receiver by a noise as a function of caller, receiver, and noise-source location, distance relative to each other, and received level of the call.

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Vocalization changes may result from a need to compete with an increase in background noise and include increasing the source level, modifying the frequency, increasing the call repetition rate of vocalizations, or ceasing to vocalize in the presence of increased noise (Hotchkin and Parks 2013). In cetaceans, vocalization changes were reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying ((e.g., Holt 2008a; Holt et al. 2011b; Rolland et al. 2012) as well as changes in the natural acoustic environment (Dunlop et al. 2014). Vocal changes can be temporary, or can be permanent, as seen in the increase in starting frequency for the North Atlantic right whale upcall over the last 50 years (Tennessen and Parks 2016a). This shift in frequency was modeled, and it was found that it led to increased detection ranges between right whales. The frequency shift, coupled with an increase in call intensity by 20 dB, led to a call detectability range of less than 3 to over 9 km (Tennessen and Parks 2016a). In some cases, these vocal changes may have fitness consequences, such as an increase in metabolic rates and oxygen consumption, as was found for bottlenose dolphins when increasing their call amplitude (Holt et al. 2015). A switch from vocal communication to physical, surface-generated sounds such as pectoral fin slapping or breaching was observed for humpback whales in the presence of increasing natural background noise levels, indicating that adaptations to masking may also move beyond vocal modifications (Dunlop et al. 2010). These changes all represent possible tactics by the sound-producing animal to reduce the impact of masking. The receiving animal can also reduce masking by using active listening strategies such as orienting to the sound source, moving to a different location to improve binaural cues (time or intensity differences between the ears due to a sound source's location relative to the animal's head), or going still to reduce noise associated with hydrodynamic flow. The structure of some noises (e.g., amplitude modulation) may also provide some release from masking through comodulation masking release (the difference in masking when a noise is broadband versus having the same bandwidth as the signal; Branstetter and Finneran 2008). Signal characteristics (e.g., whether the signal has harmonics, or is frequency modulated) may further enhance the detectability of a signal in noise (Cunningham et al. 2014).

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators (Allen et al. 2014; Cummings and Thompson 1971a; Cure et al. 2015), which may be reduced in the presence of a masking noise, particularly if it occurs in the same frequency band. Therefore, the occurrence of masking may prevent marine mammals from responding to the acoustic cues produced by their predators. Whether this is a possibility depends on the duration of the masking and the likelihood of encountering a predator during the time that detection and identification of predator cues are impeded. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required to attend to all killer whale calls. Similarly, sperm whales (Isojunno et al. 2016) and humpback whales (Curé et al., 2015) changed their behavior in response to killer whale vocalization playbacks. These findings indicate that some recognition of predator cues could be missed if the killer whale vocalizations were masked.

Masking as a result of sonar and other transducers

Masking could occur as a result of sonar and other transducers. As stated previously, masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Because traditional military sonars typically have low duty cycles, the effects of such masking would likely be limited when compared with continuous sources (e.g., vessel noise). Low-frequency active sonar could overlap with mysticete vocalizations (e.g., minke and humpback whales). For example, in the presence of low-frequency active sonar, humpback whales were observed to increase the length of their songs (Fristrup et al. 2003; Miller et al. 2000), possibly due to the overlap in frequencies between the whale song and the low-frequency active sonar.

Newer high duty cycle or continuous active sonars have more potential to mask vocalizations, particularly for mid-frequency cetaceans. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, high frequency acoustic sources such as pingers that operate at higher repetition rates (e.g., 2 to 10 kHz with harmonics up to 19 kHz, 76 to 77 pings per minute (Culik et al. 2001), also operate at lower source levels. While the lower source levels of these systems limits the range of impact compared to more traditional systems, animals close to the sonar source are likely to experience masking on a much longer time scale than those exposed to traditional sonars. The frequency range at which high duty cycle systems operate overlaps the vocalization frequency of a number of mid-frequency cetaceans (e.g., ESA-listed sperm whales).

Continuous noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, and acoustically-mediated cooperative behaviors such as foraging or reproductive activities. Similarly, because the systems are mid-frequency, there is the potential for the sonar signals to mask important environmental cues like predator vocalizations (e.g. killer whales), possibly affecting survivorship for targeted animals. While there are currently no available studies of the impacts of high duty cycle sonars on marine mammals, masking due to these systems is likely analogous to masking produced by other continuous sources (e.g. vessel noise and low-frequency cetaceans), and will likely have similar short-term consequences, though longer in duration due to the duration of the masking noise. These may include changes to vocalization amplitude and frequency (Brumm and Slabbekoorn 2005; Hotchkin and Parks 2013) and behavioral impacts such as avoidance of the area and interruptions to foraging or other essential behaviors (Gordon et al. 2003). Long-term consequences could include changes to vocal behavior and vocalization structure (Foote et al. 2004a; Parks et al. 2007a), abandonment of habitat if masking occurs frequently enough to significantly impair communication (Brumm and Slabbekoorn 2005), a potential decrease in survivorship if predator vocalizations are masked (Brumm and Slabbekoorn 2005), and a potential decrease in recruitment if masking interferes with reproductive activities or mother-calf communication (Gordon et al. 2003).

9.2.1.1.1.5 Behavioral Reactions

Any stimuli in the environment can cause a behavioral response in marine mammals. These stimuli include noise from anthropogenic sources such as vessels, sonar, air guns, or pile driving, but could also include the physical presence of a vessel or aircraft. However, these stimuli could also influence how or if a marine mammal responds to a sound such as the presence of predators, prey, or conspecifics. Furthermore, the response of a marine mammal to an anthropogenic sound may depend on the frequency, duration, temporal pattern and amplitude of the sound as well as the animal’s prior experience with the sound and their behavioral state (i.e., what the animal is doing and their energetic needs at the time of the exposure) (Ellison et al. 2011). The distance from the sound source and whether it is approaching or moving away can also affect the way an animal responds to a sound (Wartzok et al. 2003).

For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson et al. (1995e). Other reviews (Gomez et al. 2016; Nowacek et al. 2007; Southall et al. 2007a) addressed studies conducted since 1995 and focused on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated, and also examined the role of context. Southall et al. (2007a) synthesized data from many behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. Southall et al. (2016) reviewed the range of experimental field studies that have been conducted to measure behavioral responses of cetaceans to sonar. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007a; Southall et al. 2016). Ellison et al. (2011) outlined an approach to assessing the effects of sound on marine mammals that incorporates these contextual-based factors. They recommend considering not just the received level of sound, but also in what activity the animal is engaged, the nature and novelty of the sound (i.e., is this a new sound from the animal's perspective), and the distance between the sound source and the animal. They submit that this "exposure context" as described, greatly influences the type of behavioral response exhibited by the animal. Forney et al. (2017) also point out that an apparent lack of response (e.g. no displacement or avoidance of a sound source) may not necessarily mean there is no cost to the individual or population, as some resources or habitats may be of such high value that animals may choose to stay, even when experiencing stress or hearing loss. Forney et al. (2017) recommend considering both the costs of remaining in an area of noise exposure such as TTS, PTS or masking, which could lead to an increased risk of predation or other threats or a decreased capability to forage, and the costs of displacement, including potential increased risk of vessel strike or bycatch, increased risks of predation or competition for resources, or decreased habitat suitable for foraging, resting, or socializing.

Behavioral reactions could result from a variety of sound sources, including impulsive sources such as explosives, air guns, and impact pile driving, and non-impulsive sources such as sonar and other active acoustic sources (e.g., pingers), and vessel and aircraft noise. For some of these noise sources numerous studies exist (e.g., sonar), whereas for others the data are sparse (e.g., pile driving), and surrogate sound sources must be relied upon to assess the potential for behavioral response. Similarly, there is data on the reactions of some species in different behavioral states, providing evidence on the importance of context in gauging a behavioral response. However, for most species, little or no data exist on behavioral responses to any sound source, and so all species have been grouped into broad taxonomic groups from which general response information can be inferred.

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

Behavioral response studies have been conducted through the collaboration of various research and government organizations in Bahamian, United States (e.g., off Southern California, Hawaii, and the east coast), Mediterranean, Australian, and Norwegian waters. These studies have attempted to define and measure responses of cetaceans to controlled exposures of sonar and other sounds to understand their potential impacts better. While controlling for as many variables as possible (e.g., the distance and movement of the source), these studies also introduce additional variables that do not normally occur in a real Navy training or testing activity, including the tagging of whales, following the tagged animals with multiple vessels, and continually approaching the animal to create a dose escalation. In addition, distances of the sound source from the whales during behavioral response studies were always within 1 to 8 km. Some of these studies have suggested that ramping-up a source from a lower source level would act as a protective measure to mitigate higher order (e.g., TTS or PTS) impacts of sonar. However, this practice may only be effective for more responsive animals, and for short durations (e.g., 5 minutes) of ramp-up (von benda-Beckmann et al. 2016; Von Benda-Beckmann et al. 2014). Therefore, while these studies have provided the most information to date on behavioral responses of marine mammals to sonar, there are still many contextual factors to be teased apart and determining what might produce a significant behavioral response is currently difficult to discern.

Passive acoustic monitoring and visual observational behavioral response studies have also been conducted on Navy ranges, taking advantage of the existing seafloor hydrophones and real testing and training activity and associated sources to assess behavioral responses (Deakos and Richlen 2015; Henderson et al. 2016; Manzano-Roth et al. 2016; Martin et al. 2015; Mccarthy et al. 2011; Mobley and Deakos 2015; Moretti et al. 2014; Tyack et al. 2011b). In addition, extensive aerial, visual, and acoustic monitoring is conducted before, during and after training events to watch for behavioral responses during training and look for injured or stranded animals after training (Campbell et al. 2010; Farak et al. 2011; HDR 2011; Navy 2011b; Navy 2013a; Navy 2014b; Navy 2015; Norris et al. 2012; Smultea and Mobley 2009; Smultea et al. 2009;

Trickey et al. 2015). During all of these monitoring efforts, only a few behavioral responses were observed, and no injured or dead animal was observed that was directly related to a training event (some dead animals were observed but typically before the event or appeared to have been deceased prior to the event; e.g., Smultea et al., 2011). However, it should be noted that passive acoustic studies are limited to observations of vocally-active marine mammals and visual studies are limited to what can be observed at the surface. These study types do have the benefit of occurring in the absence of some of the added contextual variables in the controlled exposure studies. Furthermore, when visual and passive acoustic data collected during a training event are combined with ship movements and sonar use they provide a unique and realistic scenario for analysis. In addition to these types of observational behavioral response studies, Harris and Thomas (2015) highlighted additional research approaches that may provide further information on behavioral responses to sonars and other transducers beyond behavioral response type studies or passive acoustic monitoring, including conducting controlled exposures on captive animals with scaled sources (smaller sized and deployed at closer proximity), on wild animals with both scaled and real but directed sources, and predator playback studies, all of which will be discussed below.

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

Mysticetes

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

Surface feeding blue and humpback whales did not show a change in behavior in response to mid-frequency simulated and real sonar sources with received levels between 90 and 179 dB re 1 μPa, but deep feeding and non-feeding whales showed temporary reactions including cessation of feeding, reduced initiation of deep foraging dives, generalized avoidance responses, and changes to dive behavior (DeRuiter et al. 2017; Goldbogen et al. 2013b; Silve et al. 2015). These findings indicate that the behavioral state of the animal plays a role in the type and severity of a behavioral response. In fact, when the prey field was mapped and used as a covariate in similar models looking for a response in blue whales, the response in deep-feeding behavior by blue whales was even more apparent, reinforcing the need for contextual variables to be included when assessing behavioral responses (Friedlaender et al. 2016). However, even when responses did occur, the animals quickly returned to their previous behavior after the sound exposure ended (Goldbogen et al. 2013b; Silve et al. 2015). In another study, humpback whales exposed to a 3 kHz pinger meant to act as a net alarm to prevent entanglement did not respond or change course, even when within 500 m (Harcourt et al. 2014). Five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives. In this case, the alarm was comprised of a mixture of signals with frequencies from 500 to 4500 Hz, was long in duration (lasting several minutes), and was purposely designed to elicit a reaction from the animals as a prospective means of protecting them from ship strikes (Nowacek et al. 2004). Although the animals' received SPL was similar in the latter two studies (133–150 dB re 1 μPa), the frequency, duration, and temporal pattern of signal presentation were different.

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

The strongest baleen whale response in any behavioral response study was observed in a minke whale in the 3S2 study (i.e., the second phase of the 3S study), which responded at 146 dB re 1 μPa by strongly avoiding the sound source (Kvadsheim et al. 2017; Silve et al. 2015). Although the minke whale increased its swim speed, directional movement and respiration rate, none of these were greater than rates observed in baseline behavior, and its dive behavior remained similar to baseline dives. A minke whale tagged in the SOCAL BRS study also responded by increasing its directional movement, but maintained their speed and dive patterns, so did not demonstrate as strong of a response (Kvadsheim et al. 2017). In addition, the 3S2 minke whale demonstrated some of the same avoidance behavior during the controlled ship approach with no sonar, indicating at least some of the response was to the vessel (Kvadsheim et al. 2017). Martin et al. (2015) found that the density of calling minke whales was reduced during periods of Navy training involving sonar relative to the periods before training, and increased again in the days after training was completed. The responses of individual whales could not be assessed, so in this case it is unknown whether the decrease in calling animals indicated that the animals left the range, or simply ceased calling. Similarly, minke whale detections made using Marine Acoustic Recording Instruments off Jacksonville, Florida were reduced or ceased altogether during periods of sonar use (Navy 2013c; Norris et al. 2012) especially with an increased ping rate (Charif et al. 2015). Two minke whales also stranded in shallow water after the US Navy training event in the Bahamas in 2000, although these animals were successfully returned to deep water with no physical examinations. Because there were no physical examinations of these animals, no final conclusions were drawn on whether the sonar led to their stranding (Commerce 2001; Filadelfo et al. 2009a; Filadelfo et al. 2009b).

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

Opportunistic passive acoustic based studies have also detected behavioral responses to sonar. Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low-frequency calls usually associated with feeding behavior, beginning at received levels of 110 to 120 dB re 1 μPa (Melcon et al. 2012). In another example, Risch et al. (2012) determined that humpback whale song produced in the Stellwagen Bank National Marine Sanctuary was reduced, and since the timing was concurrent with an Ocean Acoustic Waveguide

Remote Sensing experiment occurring 200 km away, they concluded that the reduced song was a result of the Ocean Acoustic Waveguide Remote Sensing experiment. However, Gong et al. (2014) analyzed the same data set while also looking at the presence of herring in the region, and found that the singing humpbacks were actually located on nearby Georges Bank and not on Stellwagen, and that the song rate in their data did not change in response to the Ocean Acoustic Waveguide Remote Sensing experiment, but could be explained by natural causes.

Although some strong responses have been observed in mysticetes to sonar and other active acoustic sources (e.g., the single minke whale), for the most part mysticete responses appear to be fairly moderate across all received levels. While some responses such as cessation of foraging or changes in dive behavior could carry short-term impacts, in all cases behavior returned to normal after the signal stopped. Mysticete responses also seem to be highly mediated by behavioral state, with no responses occurring in some behavioral states, and contextual factors and signal characteristics having more impact than received level alone. Many of the contextual factors resulting from the behavioral response studies (e.g., close approaches by multiple vessels or tagging) would not likely occur during real Navy testing and training scenarios. While there is a lack of data on behavioral responses of mysticetes to continuously active sonars, these species are known to be able to habituate to novel and continuous sounds (Nowacek et al. 2004), suggesting that they could have similar responses to high duty cycle sonars. No significant behavioral responses such as panic or stranding have been observed during monitoring of actual training exercises (Navy 2011b; Navy 2014a; Smultea et al. 2009; Watwood et al. 2012a).

Odontocetes

Behavioral response studies have been conducted on odontocete species since 2007, with a focus on beaked whale (not ESA-listed) responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge and Durban 2009; Claridge et al. 2009; Henderson et al. 2015; Mccarthy et al. 2011; Moretti et al. 2009; Southall et al. 2013; Southall et al. 2012; Southall et al. 2011; Southall et al. 2014). Though below we will discuss results of behavioral response studies on many odontocete species (e.g., beaked whales), sperm whales are the only odontocete in the action area listed under the ESA. Results to date suggest that sperm whales are not as sensitive to anthropogenic sound sources as some other odontocetes, such as beaked whales (Southall et al. 2009).

Observed reactions by Blainville's, Cuvier's, and Baird's beaked whales to mid-frequency sonar sounds have included cessation of clicking, termination of foraging dives, changes in direction to avoid the sound source, slower ascent rates to the surface, and other unusual dive behavior (Boyd et al. 2008; Deruiter et al. 2013a; Miller et al. 2015; Southall et al. 2011; Stimpert et al. 2014; Tyack et al. 2011a). A response was observed in a northern bottlenose whale, which conducted the longest and deepest dive on record for that species after the sonar exposure and continued swimming away from the source for over 7 hours (Miller et al. 2015). Responses occurred at received levels between 95 and 150 dB re 1 μPa. All of these exposures occurred within 1–8 km of the focal animal, within a few hours of tagging the animal, and with one or more boats within a few kilometers to observe responses and record acoustic data. One Cuvier's beaked whale was also incidentally exposed to real Navy sonar located over 100 km away, and the authors did not detect similar responses at comparable received levels. Received levels from the mid-frequency active sonar signals from the controlled and incidental exposures were calculated as 84 to 144 and 78 to 106 dB re 1 μPa, respectively, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor in the responses to the simulated sonars (Deruiter et al. 2013a). Furthermore, recent long-term tagging work has demonstrated that the longer duration dives considered a behavioral response by Deruiter et al. (2013a) fell within the normal range of dive durations found for eight tagged Cuvier's beaked whales on the Southern California Offshore Range (Schorr et al. 2014). However, the longer inter-deep dive intervals found by Deruiter et al. (2013a) were among the longest found by Schorr et al. (2014) and could indicate a response to sonar. In addition, Williams et al. (2017) note that in normal deep dives or during fast swim speeds, beaked whales and other marine mammals use strategies to reduce their stroke rates, including leaping or wave surfing when swimming, and interspersing glides between bouts of stroking when diving. They determined that in the post-exposure dives by the tagged Cuvier's beaked whales described in DeRuiter et al. (2013b), the whales ceased gliding and swam with almost continuous strokes. This change in swim behavior was calculated to increase metabolic costs about 30.5 percent and increase the amount of energy expending on fast swim speeds from 27 to 59 percent of their overall energy budget. This repartitioning of energy was detected in the model up to 1.7 hours after the single sonar exposure. Therefore, while the overall post-exposure dive durations were similar, the metabolic energy calculated by Williams et al. (2017a) was higher.

On Navy ranges, Blainville's beaked whales located on the range appear to move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge and Durban 2009; Claridge et al. 2009; Henderson et al. 2015; Mccarthy et al. 2011; Moretti et al. 2009; Tyack et al. 2011a). However, Blainville's beaked whales remain on the range to forage throughout the rest of the year (Henderson et al., 2016), possibly indicating that this a preferred foraging habitat regardless of the effects of the noise, or it could be that there are no long term consequences of the sonar activity. Similarly, photo identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in 1 or more prior years, with re-sightings up to 7 years apart, indicating a possibly resident population on the range (Falcone and Schorr 2014; Falcone et al. 2009).

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

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

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

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

Other opportunistic observations of behavioral responses to sonar have occurred as well, although in those cases it is difficult to attribute observed responses directly to the sonar exposure, or to know exactly what form the response took. For example, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test, with transmissions centered at 57 Hz and up to 220 dB re 1 μPa (Bowles et al. 1994), although it could not be determined whether the animals ceased sound production or left the area. In May 2003, killer whales in Haro Strait, Washington exhibited what were believed by some observers to be aberrant behaviors, during which time the *USS Shoup* was in the vicinity and engaged in mid-frequency active sonar operations. Sound fields modeled for the *USS Shoup* transmissions (Fromm 2009; Navy 2003; NMFS 2005a) estimated a mean received SPL of approximately 169 dB re 1 μPa at the location of the killer whales at the closest point of approach between the animals and the vessel (estimated SPLs ranged from 150 to 180 dB re 1 μPa). However, attributing the observed behaviors to any one cause is problematic given there were six nearby whale watch vessels surrounding the pod, and subsequent research has demonstrated that "Southern Residents modify their behavior by increasing surface activity (breaches, tail slaps, and pectoral fin slaps) and swimming in more erratic paths when vessels are close" (NOAA 2014c). Several odontocete species, including bottlenose dolphins, Risso's dolphins, Pacific white-sided dolphins, and common dolphins have been observed near the Southern California Offshore Range during periods of mid-frequency active sonar; responses included changes in or cessation of vocalizations, changes in behavior, and leaving the area, and at the highest received levels animals were not present in the area at all (Henderson et al. 2014). However, these observations were conducted from a vessel off-range, and so any observed responses could not be attributed to the sonar with any certainty. Research on sperm whales in the Caribbean in 1983 coincided with the U.S. intervention in Grenada, where animals were observed scattering and leaving the area in the presence of military sonar, presumably from nearby submarines (Watkins 1985; Watkins and Schevill 1975). The authors did not report received levels from these exposures and reported similar reactions from noise generated by banging on their boat hull; therefore, it was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general.

During aerial and visual monitoring of Navy training events involving sonar, rough-toothed dolphins and unidentified dolphins were observed approaching the vessel with active sonar as if to bowride, while spotted dolphins were observed nearby but did not avoid or approach the vessel (HDR 2011; Navy 2011a; Watwood et al. 2012b). During small boat surveys near the Navy's Southern California Offshore Range in southern California, more dolphins were encountered in June compared to a similar survey conducted the previous November after 7 days of mid-frequency sonar activity. It was not investigated if this change was due to the sonar activity or was a seasonal difference that could be observed in other years (Campbell et al. 2010). There were also fewer passive acoustic dolphin detections during and after longer sonar activities in the Marianas Islands Range Complex, with the post-activity absence lasting longer than the mean dolphin absence of two days when sonar was not present (Munger et al. 2014; Munger et al. 2015).

Acoustic harassment devices and acoustic deterrent devices have been used to deter marine mammals from approaching fishing gear both to prevent entanglement and to reduce depredation (taking fish). These devices have been used successfully to deter harbor porpoises and beaked whales from getting entangled in fishing nets. For example, Kyhn et al. (2015) tested two types of pingers, one with a 10 kHz tone and one with a broadband 30 to 160 kHz sweep. Porpoise detection rates were reduced by 65 percent for the sweep and 40 percent for the tone and, while there was some gradual habituation after the first 2 to 4 exposures, longer term exposures (over 28 days) showed no evidence of additional habituation. Additionally, sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins and Schevill 1975). Acoustic harassment devices used to deter marine mammals from depredating long lines or aquaculture enclosures have proven less successful. For example, Tixier et al. (2014) used a 6.5 kHz pinger with a source level of 195 dB re 1 μPa on a longline to prevent depredation by killer whales, and although two groups of killer whales fled over 700 m away during the first exposure, they began depredating again after the third and seventh exposures, indicating rapid habituation. In a review of marine mammal deterrents, Schakner and Blumstein (2013) point out that both the characteristics of deterrents and the motivation of the animal play a role in the effectiveness of acoustic harassment devices. Deterrents that are strongly aversive either simulate a predator or are otherwise predictive of a threat are those more likely to be effective, unless the animal habituates to the signal or learns that there is no true threat associated with the signal. In some cases the net pingers may create a "dinner bell effect", where marine mammals have learned to associate the signal with the availability of prey (Jefferson and Curry 1996; Schakner and Blumstein 2013). This may be why net pingers have been more successful at reducing entanglements for harbor porpoise and beaked whales because these species are not depredating from the nets but are getting entangled when foraging in the area and are unable to detect the net (Carretta and Barlow 2008; Schakner and Blumstein 2013). Additional behavioral studies have been conducted with captive harbor porpoises using acoustic alarms, such as those used on fishing nets to help deter marine mammals from becoming caught or entangled (Kastelein et al. 2001; Kastelein et al. 2006). These studies have found that high-frequency sources with varied duration, interval, and sweep characteristics can prove to be effective deterrents for harbor porpoises (Kastelein et al. 2017).

Controlled experiments have also been conducted on captive animals to estimate received levels at which behavioral responses occur. In one study, bottlenose dolphin behavioral responses were recorded when exposed to 3 kHz sonar-like tones between 115 and 185 dB re 1 μPa (Houser et al. 2013), and in another study bottlenose dolphins and beluga whales were presented with 1-second tones up to 203 dB re 1 μPa to measure TTS (Finneran et al. 2001; Finneran et al. 2005; Finneran and Schlundt 2004; Schlundt et al. 2000). During these studies, responses included changes in respiration rate, fluke slaps, and a refusal to participate or return to the location of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002; Schlundt et al. 2000). In the behavioral response experiment, bottlenose dolphins demonstrated a 50 percent probability of response at 172 dB re 1 μPa over 10 trials, and in the TTS study bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa, and beluga whales did so at received levels of 180 to 196 dB re 1 μPa and above. In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000). While animals were commonly reinforced with food during these studies, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to noise sources.

Behavioral responses to a variety of sound sources have been studied in harbor porpoises, including acoustic alarms (Kastelein et al. 2001; Kastelein et al. 2006), emissions for underwater data transmission (Kastelein et al. 2005), and tones, including 1 to 2 kHz and 6 to 7 kHz sweeps with and without harmonics (Kastelein et al. 2014d), and 25 kHz with and without sidebands (Kastelein et al. 2015a; Kastelein et al. 2015b). Responses include increased respiration rates, more jumping, or swimming further from the source, but responses were different depending on the source. For example, harbor porpoises responded to the 1 to 2 kHz upsweep at 123 dB re 1 μPa, but not to the downsweep or the 6 to 7 kHz tonal at the same level (Kastelein et al. 2014d). When measuring the same sweeps for a startle response, the 50 percent response threshold was 133 and 101 dB re 1 μPa for 1 to 2 kHz and 6 to 7 kHz sweeps respectively when no harmonics were present, and decreased to 90 dB re 1 μPa for 1 to 2 kHz sweeps with harmonics present

(Kastelein et al. 2014d). Harbor porpoises responded broadband signals up to 44 kHz with a slight respiration response at 117 dB re 1 μPa and an avoidance response at 139 dB re 1 μPa, but another source with a fundamental (lowest and strongest) frequency of 18 kHz didn't have an avoidance response until 151 dB re 1 μPa (Kastelein et al. 2014a). Exposure of the same acoustic pinger to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006), again highlighting the importance of understanding species' differences in the tolerance to underwater noise, although sample sizes in these studies was small so these could reflect individual differences as well.

Behavioral responses by odontocetes to sonar and other transducers appear to run the full gamut from no response at all to responses that could potentially lead to long-term consequences for individual animals (e.g., mother-calf separation). This is likely in part due to the fact that this taxonomic group is so broad and includes some of the most sensitive species (e.g., beaked whales and harbor porpoise) as well as some of the least sensitive species (e.g., bottlenose dolphins). This is also the only group for which both field behavioral response studies and captive controlled exposure experiments have been conducted, leading to the assessment of both contextually-driven responses as well as dose-based responses. This wide range in both exposure situations and individual- and species-sensitivities makes reaching general conclusions difficult. However, it does appear as though exposures in close proximity, with multiple vessels that approach the animal, lead to higher-level responses in most odontocete species regardless of received level or behavioral state. In contrast, in more "real-world" exposure situations, with distant sources moving in variable directions, behavioral responses appear to be driven by behavioral state, individual experience, or species-level sensitivities. These responses may also occur more in-line with received level such that the likelihood of a response would increase with increased received levels. However, these "real-world" responses are more likely to be short-term, lasting the duration of the exposure.

9.2.1.1.1.6 Stranding

Marine mammals are subjected to a variety of natural and anthropogenic factors acting alone or in combination that may cause a marine mammal to strand (Geraci et al. 1999; Geraci and Lounsbury 2005). When a marine mammal (alive or dead) swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a "stranding" (Geraci et al. 1999; Geraci and Lounsbury 2005; Perrin and Geraci 2002). A stranding can also occur away from the shore if the animal is unable to cope in its present situation (e.g. disabled by a vessel strike, out of habitat; Geraci and Lounsbury, 2005). Under U.S. law, a stranding is an event in the wild in which: (1) a marine mammal is dead and is (a) on a beach or shore of the United States; or (b) in waters under the jurisdiction of the United States (including any navigable waters); or (2) a marine mammal is alive and is (a) on a beach or shore of the United States and is unable to return to the water; (b) on a beach or shore of the United States and, although able to return to the water, is in need of medical attention; or (c) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance" (16 U.S.C. section 1421h).

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

Along the coasts of the continental United States and Alaska between 2001 and 2009, there were on average approximately 12,545 cetacean strandings per year (Navy 2017a). Several mass strandings (strandings that involve two or more cetaceans of the same species, excluding a single mother-calf pair) that have occurred over the past two decades have been associated with anthropogenic activities that introduced sound into the marine environment such as naval operations and seismic surveys. An in-depth discussion of strandings is in the Navy's Technical Report on *Marine Mammal Strandings Associated with U.S. Navy Sonar Activities* (Navy 2017d).

Sonar use during exercises involving the U.S. Navy has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira Island, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Cox et al. 2006; Fernandez et al. 2006; Navy 2017d). These five mass strandings have resulted in about 40 known cetacean deaths consisting mostly of beaked whales (not ESA-listed) and with potential linkages to mid-frequency active sonar activity. In these circumstances, exposure to non-impulsive acoustic energy was considered a potential indirect cause of death of the marine mammals (Cox et al. 2006). Strandings of other marine mammal species have not been as closely linked to sonar exposure, but rather, have typically been attributed to natural or anthropogenic factors other than sonar.

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

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

9.2.1.1.1.7 Potential for Long-term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. Physical effects that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. Depending on the severity and duration, temporary impacts to hearing (i.e., temporary threshold shift) also have the potential to impact the fitness of individual animals, and potentially, populations. The long-term consequences due to individual behavioral reactions and short-term or chronic instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. Of critical importance in discussion on the potential consequences of disturbance is the health of the individual animals disturbed, and the trajectory of the population those individuals comprise. The consequences of disturbance, particularly repeated disturbance, would be more significant if the affected animal were already in poor condition as such animals would be less likely to compensate for additional energy expenditures or lost foraging or reproductive opportunities. However, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences. It is more likely that any long-term consequences to an individual would be a result of costs accumulated over a season, year, or life stage due to multiple behavioral or stress responses resulting from exposure to many sound-producing activities over significant periods.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area (Wartzok et al. 2003). Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region (Bejder et al. 2006b; Blackwell et al. 2004; Teilmann et al. 2006). Gray whales in Baja California abandoned a historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. However, whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al. 1984a). Mysticetes in the northwest Atlantic tended to adjust to vessel traffic over a number of years, trending towards more neutral responses to passing vessels (Watkins 1986b), indicating that some animals may habituate or otherwise learn to cope with high levels of human activity. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Moore and Barlow (2013) noted a decline in the overall beaked whale population in a broad area of the Pacific Ocean along the U.S. west coast. Moore and Barlow (2013) provide several hypotheses for the decline of beaked whales in those waters, one of which is anthropogenic sound including the use of sonar by the U.S. Navy. However, new data has been published raising uncertainties over whether a decline in the beaked whale population occurred off the U.S. west coast between 1996 to 2014 (Barlow 2016). Photo identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years and re-sightings up to 7 years apart (Falcone and Schorr 2014; Falcone et al. 2009). These results indicate long-term residency by individuals in an intensively used Navy training and testing area, which may suggest a lack of long-term consequences as a result of exposure to Navy training and testing activities, but could also be indicative of high-value resources that exceed the cost of remaining in the area. Long-term residency does not mean there has been no impact to population growth rates and there are no data existing on the reproductive rates of populations inhabiting the Navy range area around San Clemente Island as opposed to beaked whales from other areas. In that regard however, recent results from photo-identifications are beginning to provide critically needed calving and weaning rate data for resident animals on the Navy's Southern California range. Three adult females that had been sighted with calves in previous years were again sighted in 2016, one of these with her second calf, and a fourth female that was first identified in 2015 without a calf, was sighted in 2016 with a calf (Schorr et al. 2017). Resident females documented with and without calves from year to year will provide the data for this population that can be applied to future research questions.

Research involving three tagged Cuvier's beaked whales in the Southern California Range Complex reported on by Falcone and Schorr (2014) has documented movements in excess of hundreds of kilometers by some of those animals. Schorr et al. (2014) reported the results for an additional eight tagged Cuvier's beaked whales in the same area. Five of these eight whales made journeys of approximately 250 km from their tag deployment location, and one of these five made an extra-regional excursion over 450 km south to Mexico and back again. Baleen whales also have extensive ranges, often exceeding thousands of miles. Given that some beaked whales may routinely move hundreds of kilometers as part of their normal pattern (Schorr et al. 2014), and baleen whales also travel great distances, temporarily leaving an area to avoid sonar or other anthropogenic activity may have little cost.

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

The Population Consequences of Acoustic Disturbance model (NRC 2005) proposes a conceptual model for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population. In 2009, the U.S. Office of Naval Research set up a working group to transform the Population Consequences of Acoustic Disturbance framework into a mathematical model and include other stressors potentially causing disturbance in addition to noise. The model, now called Population Consequences of Disturbance, has been used for case studies involving bottlenose dolphins, North Atlantic right whales, beaked whales, southern elephant seals, California sea lions, blue whales, humpback whales, and harbor porpoise (Costa et al. 2016a; Costa et al. 2016b; Harwood et al. 2014; Hatch et al. 2012; King et al. 2015a; New et al. 2014; New et al. 2013a; New et al. 2013b), but the Population Consequences of Disturbance model is still in the preliminary stages of development.

Costa et al. (2016b) emphasized taking into account the size of an animal's home range, whether populations are resident and non-migratory or if they migrate over long areas and share their feeding or breeding areas with other populations. These factors, coupled with the extent, location, and duration of a disturbance can lead to markedly different impact results. For example, Costa et al. (2016b) modeled seismic surveys with different radii of impacts on the foraging grounds of Bering Sea humpback whales, West Antarctic Peninsula humpback whales, and California Current blue whales, and used data from tagged whales to determine foraging locations and effort on those grounds. They found that for the blue whales and the West Antarctic humpback whales, less than 19 percent and 16 percent (respectively) of each population would be exposed, and less than 19 percent and 6 percent of foraging behavior would be disturbed. This was likely due to the fact that these populations forage for krill over large areas. In contrast, the Bering Sea population of humpback whales had over 90 percent of the population exposed when the disturbance zones extended beyond 50 km, and 100 percent of their foraging behavior was disturbed when the zone was over 25 km. These animals forage for fish over a much smaller area, thereby having a limited range for foraging that can be disturbed. Similarly, (Costa et al. 2016a) placed similar disturbance zones in the foraging and transit areas of northern elephant seals and California sea lions. Again, the location and radius of disturbance impacted how many animals were exposed and for how long, with California sea lions disturbed for a longer period than elephant seals, which extend over a broader foraging and transit area. However, even the animals exposed for the longest periods had negligible modeled impacts to their reproduction and pup survival rates.

Using the Population Consequences of Disturbance framework, modeling of the long-term consequences of exposure has been conducted for a variety of marine mammal species and stressors. Even when high and frequent exposure levels are included, few long-term consequences have been predicted. For example, De Silva et al. (2014) conducted a population viability analysis on the long-term impacts of pile driving and construction noise on harbor porpoises and bottlenose dolphins. Despite including the conservative assumptions that 25 percent of animals that received PTS would die, and that behavioral displacement from an area would lead to breeding failure, the model only found short-term impacts to the population size and no long-term effects on population viability.

The Population Consequences of Disturbance model developed by New et al. (2013b) predicted that beaked whales require energy dense prey and high quality habitat, and that non-lethal disturbances that displace whales from that habitat could lead to long-term impacts on fecundity and survival. However, the authors used many conservative assumptions within their model since many parameters are unknown for beaked whales. As discussed above in Schorr et al. (2014), beaked whales have been tracked roaming over distances of 250 km or more indicating that temporary displacement from a small area may not preclude finding prey or suitable habitat. Another Population Consequences of Disturbance model developed in New et al. (2014) predicted elephant seal populations to be relatively robust even with a greater than 50 percent reduction in foraging trips. Even with this very high level of disruption which would not be expected to occur due to Navy activities, only a slight (0.4 percent) population decline was modeled to occur in the following year. It should be noted that in all of these models, assumptions were made, and many input variables were unknown and so were estimated using available data. It is still not possible to utilize individual short-term behavioral responses to estimate long-term or population level effects.

The best assessment of long-term consequences from Navy training and testing activities come from monitoring marine mammal populations over time within the action area. A U.S. workshop on marine mammals and sound indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival (Fitch et al. 2011). The Navy has developed and implemented comprehensive monitoring plans since 2009 for protected marine mammals occurring on Navy ranges with the goal of assessing the impacts of training and testing activities on marine species and the effectiveness of the Navy's current mitigation practices. The results of this long-term monitoring are now being compiled and analyzed for trends in occurrence or abundance over time (e.g., Martin et al. 2017). Preliminary results of this analysis at the Pacific Missile Range Facility in Hawaii indicate no changes in detection rates for several species over the past decade. Continued monitoring efforts over time will help evaluate the long-term consequences of exposure to noise sources.

9.2.1.1.2 Exposure Analysis

Section 2.2.1 presented information on the criteria and thresholds used to estimate impacts to marine mammals from sonar and other transducers. Additional information on these criteria is described in the technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017b). This section presents information on the range to effects for different sonar sources, the estimated number of exposures of ESA-listed marine mammals to sonar and other transducers that are expected to rise to the level of take under the ESA, the expected magnitude of effect from those exposures, and the likely responses of the animals to those effects. The exposure estimates were produced by the Navy's NAEMO modeling. We consider these estimates to be the best available data on exposure of marine mammals and sea turtles to acoustic stressors from the proposed action and the estimates of take resulting from this analysis are reasonably certain to occur.

For sonar and other transducers (and explosives; see Section 9.2.1.2), we considered exposure estimates from the Phase III NAEMO model at two output points for marine mammals (and sea turtles, see Section 9.2.2). First, we estimated the total number of ESA-listed species (animats) that would be exposed to acoustic sources prior to the application of a dose-response curve or criteria. We term these the "unprocessed" estimates. This estimate is the number of times individual animats or animals are likely to be exposed to the acoustic environment that is a result of training or testing activities, regardless of whether they are injured or respond in a way that would significantly disrupt normal behavioral patterns as a result of that exposure. In most cases, the number of animals "taken" (under the ESA) by an action would be a subset of the number of animals that are exposed to the action because (1) in some circumstances, animals might not respond to an exposure or (2) some responses may be negative for an individual animal without constituting a form of "take" under the ESA. A second set of exposure estimates ("model-estimated") of listed species were generated and "processed" using dose-response curves and criteria for TTS and PTS developed by the Navy and NMFS' Permits Division.

Any modeled instances of injury and mortality are further analyzed to account for the mitigation proposed by the Navy to avoid impacts to marine mammals and avoidance responses that would be expected from individual animals once they sense the presence of Navy acoustic stressors (post-processing; see the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts on Marine Mammals and Sea Turtles* (Navy 2018b)]). Procedural mitigation measures are expected to reduce the likelihood of injury or mortality, but would not further reduce potential behavioral response impacts to lesser impacts due to the potential distance from the source stressor. Consideration of avoidance and mitigation reduces some modeled instances of injury to instances of non-injurious effects (e.g., a significant disruption of normal behavioral patterns), but such impacts are not reduced in the post-processing stage. The final take estimates for marine mammals (and sea turtles; see Section 9.2.2) from acoustic stressors are the result of the acoustic analysis, including acoustic effects analysis, followed by consideration of animal avoidance of multiple exposures and Navy mitigation measures. We consider the modeling conclusions from the Navy's analysis to represent the best available data on exposure of marine mammals (and sea turtles) to acoustic stressors from the proposed action and the estimates of impacts (e.g., non-auditory injury, PTS, TTS, significant disruption of behavior) resulting from this analysis are reasonably certain to occur.

Range to Effects

The following tables provide range to effects for sonar and other active acoustic sources to these specific criteria, as they were used in NAEMO. Marine mammals within these ranges would be predicted to receive the associated effect. The ranges to the PTS threshold for an exposure of 30 seconds are shown in Table 68 relative to the marine mammal's functional hearing group. This period (30 seconds) was chosen based on examining the maximum amount of time a marine mammal would realistically be exposed to levels that could cause the onset of PTS based on platform (e.g., ship) speed and a nominal animal swim speed of approximately 1.5 m per second. The ranges provided in the table include the average range to PTS, as well as the range from the minimum to the maximum distance at which PTS is possible for each hearing group. For a SQS-53C (i.e., bin MF1) sonar transmitting for 30 seconds at 3 kHz and a source level of 235 dB re 1 μPa^2-s at 1 m, the average range to PTS for the low-frequency cetaceans extends from the source to a range of 66 m. PTS ranges for mid-frequency cetaceans, are much shorter. Since any hull-mounted sonar, such as the SQS-53, engaged in anti-submarine warfare training would be moving at between 10 to 15 knots and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 257 m during the time between those pings (note: 10 knots is the speed used in the Navy Acoustic Effects Model). As a result, there is no overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). For all other bins (besides MF1), PTS ranges are short enough that marine mammals (with a nominal swim speed of approximately 1.5 m per second) should be able to avoid higher sound levels capable of causing onset PTS within this 30-second period.

Table 68. Range to PTS for five representative sonar systems (Navy 2017a).

Functional Hearing Group	Approximate PTS (30 seconds) Ranges (meters)[1]				
	Sonar Bin LF5 (Low Frequency Sources <180 dB Source Level)	Sonar Bin MF1 (e.g., SQS-53 ASW Hull Mounted Sonar)	Sonar Bin MF4 (e.g., AQS-22 ASW Dipping Sonar)	Sonar Bin MF5 (e.g., SSQ-62 ASW Sonobuoy)	Sonar Bin HF4 (e.g., SQS-20 Mine Hunting Sonar)
Low-frequency Cetaceans	0 (0—0)	66 (65—80)	15 (15—18)	0 (0—0)	0 (0—0)
Mid-frequency Cetaceans	0 (0—0)	16 (16—16)	3 (3—3)	0 (0—0)	1 (0—2)

[1] PTS ranges extend from the sonar or other active acoustic sound source to the indicated distance. The average range to PTS is provided as well as the range from the estimated minimum to the maximum range to PTS in parenthesis.
Note: ASW: anti-submarine warfare; LF: low frequency; MF: mid-frequency; PTS: permanent threshold shift; NA: Not applicable because there is no overlap between species and sound source

The tables below illustrate the range to TTS for 1, 30, 60, and 120 seconds from five representative sonar systems (See Table 69 through Table 72). Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer. Therefore, successive pings can be expected to add together, further increasing the range to onset-TTS.

Table 69. Ranges to TTS for an example low-frequency sonar bin (LF5) over a representative range of environments within the action area (Navy 2017a).

Functional Hearing Group	Approximate TTS Ranges (meters)[1]			
	Sonar Bin LF5 (Low Frequency Sources <180 dB Source Level)			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency Cetaceans	4 (0—5)	4 (0—5)	4 (0—5)	4 (0—5)
Mid-frequency Cetaceans	222 (200—310)	222 (200—310)	331 (280—525)	424 (340—800)

[1]Ranges to TTS represent the model predictions in different areas and seasons within the action area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.
Note: TTS: temporary threshold shift; LF: low frequency.

Table 70. Ranges to TTS for an example mid-frequency sonar bin (MF1) over a representative range of environments within the action area (Navy 2017a).

Functional Hearing Group	Approximate TTS Ranges (meters)[1]			
	Sonar Bin MF1 (e.g., SQS-53 ASW Hull Mounted Sonar)			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency Cetaceans	1111 (650—2775)	1111 (650—2775)	1655 (800—3775)	2160 (900—6525)
Mid-frequency Cetaceans	222 (200—310)	222 (200—310)	331 (280—525)	424 (340—800)

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

Table 71. Ranges to TTS for an example mid-frequency sonar bin (MF5) over a representative range of environments within the action area (Navy 2017a).

Functional Hearing Group	Approximate TTS Ranges (meters)[1]			
	Sonar Bin MF5 (e.g., SSQ-62 ASW Sonobuoy)			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency Cetaceans	11 (0—14)	11 (0—14)	16 (0—20)	23 (0—25)
Mid-frequency Cetaceans	5 (0—10)	5 (0—10)	12 (0—15)	17 (0—22)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the action area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.
Note: ASW: anti-submarine warfare; MF: mid-frequency; TTS: temporary threshold shift

Table 72. Ranges to TTS for an example high-frequency sonar bin (HF4) over a representative range of environments within the action area (Navy 2017a).

Functional Hearing Group	Approximate TTS Ranges (meters)[1]			
	Sonar Bin HF4 (e.g., SQS-20 Mine Hunting Sonar)			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency Cetaceans	1 (0—3)	3 (0—5)	5 (0—7)	7 (0—12)
Mid-frequency Cetaceans	10 (7—17)	19 (11—35)	27 (17—60)	39 (22—100)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the action area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.
Note: HF: high frequency; TTS: temporary threshold shift

The range to received sound levels in 6-dB steps from five representative sonar bins and the percentage of animals that may exhibit a potentially significant behavioral response under each behavioral response function are shown in Table 73 through Table 77. Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group that are therefore not included in the estimated take. Table 73 illustrates the potentially significant behavioral response for low frequency active sonar. Table 74 through Table 76 illustrates the potentially significant behavioral response for mid-frequency active sonar. Table 77 illustrates the range to a potentially significant behavioral response for high-frequency active sonar.

Table 73. Ranges to a potentially significant behavioral response for an example low frequency sonar bin (LF5) over a representative range of environments within the action area (Navy 2017a).

Received Level (dB re 1 μPa)	*Mean Range (m) with minimum to maximum values in parentheses*	*Probability of Behavioral Response*		
		Odontocetes	*Mysticetes*	*Pinnipeds*
196	0 (0—0)	100%	100%	100%
190	0 (0—0)	100%	98%	99%
184	0 (0—0)	99%	88%	98%
178	1 (0—1)	97%	59%	92%
172	2 (1—2)	91%	30%	76%
166	4 (1—6)	78%	20%	48%
160	10 (1—13)	58%	18%	27%
154	21 (1—25)	40%	17%	18%
148	46 (1—60)	29%	16%	16%
142	104 (1—140)	25%	13%	15%
136	242 (120—430)	23%	9%	15%
130	573 (320—1,275)	20%	5%	15%
124	1,268 (550—2,775)	17%	2%	14%
118	2,733 (800—6,525)	12%	1%	13%
112	5,820 (1,025—18,275)	6%	0%	9%
106	13,341 (1,275—54,525)	3%	0%	5%
100	31,026 (2,025—100,000*)	1%	0%	2%

** Indicates maximum range of acoustic model, a distance of approximately 100 kilometers from the sound source.*

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (See Table 4 for behavioral cut-off distances). dB re 1 μPa²-s: decibels referenced to 1 micropascal squared second; m: meters.

Table 74. Ranges to a potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF1) over a representative range of environments within the action area (Navy 2017a).

Received Level (dB re 1 μPa)	*Mean Range (m) with minimum to maximum values in parentheses*	*Probability of Behavioral Response*		
		Odontocetes	*Mysticetes*	*Pinnipeds*
196	109 (100—150)	100%	100%	100%
190	257 (220—370)	100%	98%	99%
184	573 (400—1,000)	99%	88%	98%
178	1,235 (725—3,525)	97%	59%	92%
172	3,007 (875—9,775)	91%	30%	76%
166	6,511 (925—19,525)	78%	20%	48%
160	11,644 (975—36,275)	58%	18%	27%
154	18,012 (975—60,775)	40%	17%	18%
148	26,037 (1,000—77,525)	29%	16%	16%
142	33,377 (1,000—100,000*)	25%	13%	15%
136	41,099 (1,025—100,000*)	23%	9%	15%
130	46,618 (3,275—100,000*)	20%	5%	15%
124	50,173 (3,525—100,000*)	17%	2%	14%
118	52,982 (3,775—100,000*)	12%	1%	13%
112	56,337 (4,275—100,000*)	6%	0%	9%
106	60,505 (4,275—100,000*)	3%	0%	5%
100	62,833 (4,525—100,000*)	1%	0%	2%

** Indicates maximum range of acoustic model, a distance of approximately 100 kilometers from the sound source.*
Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (See Table 4 for behavioral cut-off distances). dB re 1 μPa²-s: decibels referenced to 1 micropascal squared second; m: meters.

Table 75. Ranges to potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF4) over a representative range of environments within the action area (Navy 2017a).

Received Level (dB re 1 μPa)	*Mean Range (m) with minimum to maximum values in parentheses*	*Probability of Behavioral Response*		
		Odontocetes	*Mysticetes*	*Pinnipeds*
196	8 (1—10)	100%	100%	100%
190	17 (1—21)	100%	98%	99%
184	35 (1—40)	99%	88%	98%
178	71 (1—95)	97%	59%	92%
172	156 (110—410)	91%	30%	76%
166	431 (280—1,275)	78%	20%	48%
160	948 (490—3,525)	58%	18%	27%
154	1,937 (750—10,025)	40%	17%	18%
148	3,725 (1,025—20,525)	29%	16%	16%
142	7,084 (1,525—38,525)	25%	13%	15%
136	11,325 (1,775—56,275)	23%	9%	15%
130	16,884 (1,775—74,275)	20%	5%	15%
124	24,033 (2,275—80,775)	17%	2%	14%
118	31,950 (2,275—100,000*)	12%	1%	13%
112	37,663 (2,525—100,000*)	6%	0%	9%
106	41,436 (2,775—100,000*)	3%	0%	5%
100	44,352 (2,775—100,000*)	1%	0%	2%

** Indicates maximum range of acoustic model, a distance of approximately 100 kilometers from the sound source.*
Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (See Table 4 for behavioral cut-off distances). dB re 1 μPa²-s: decibels referenced to 1 micropascal squared second; m: meters.

Table 76. Ranges to a potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF5) over a representative range of environments within the action area (Navy 2017a).

Received Level (dB re 1 μPa)	*Mean Range (m) with minimum to maximum values in parentheses*	*Probability of Behavioral Response*		
		Odontocetes	*Mysticetes*	*Pinnipeds*
196	0 (0—0)	100%	100%	100%
190	2 (1—3)	100%	98%	99%
184	4 (1—9)	99%	88%	98%
178	14 (1—18)	97%	59%	92%
172	29 (1—35)	91%	30%	76%
166	61 (1—80)	78%	20%	48%
160	141 (1—400)	58%	18%	27%
154	346 (1—1,000)	40%	17%	18%
148	762 (420—2,525)	29%	16%	16%
142	1,561 (675—5,525)	25%	13%	15%
136	2,947 (1,025—10,775)	23%	9%	15%
130	5,035 (1,025—17,275)	20%	5%	15%
124	7,409 (1,275—22,525)	17%	2%	14%
118	10,340 (1,525—29,525)	12%	1%	13%
112	13,229 (1,525—38,025)	6%	0%	9%
106	16,487 (1,525—46,025)	3%	0%	5%
100	20,510 (1,775—60,525)			

** Indicates maximum range of acoustic model, a distance of approximately 100 kilometers from the sound source.*
Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (See Table 4 for behavioral cut-off distances). dB re 1 μPa²-s: decibels referenced to 1 micropascal squared second; m: meters.

Table 77. Ranges to a potentially significant behavioral response for an example high frequency sonar bin (i.e., HF4) over a representative range of environments within the action area (Navy 2017a).

Received Level (dB re 1 µPa)	*Mean Range (m) with minimum to maximum values in parentheses*	*Probability of Behavioral Response*		
		Odontocetes	*Mysticetes*	*Pinnipeds*
196	3 (1—6)	100%	100%	100%
190	8 (1—14)	100%	98%	99%
184	18 (1—35)	99%	88%	98%
178	37 (1—100)	97%	59%	92%
172	78 (1—300)	91%	30%	76%
166	167 (1—725)	78%	20%	48%
160	322 (25—1,525)	58%	18%	27%
154	555 (45—3,775)	40%	17%	18%
148	867 (70—6,775)	29%	16%	16%
142	1,233 (150—12,775)	25%	13%	15%
136	1,695 (260—20,025)	23%	9%	15%
130	2,210 (470—29,275)	20%	5%	15%
124	2,792 (650—40,775)	17%	2%	14%
118	3,421 (950—49,775)	12%	1%	13%
112	4,109 (1,025—49,775)	6%	0%	9%
106	4,798 (1,275—49,775)	3%	0%	5%
100	5,540 (1,275—49,775)	1%	0%	2%

Notes: dB re 1 µPa²-s: decibels referenced to 1 micropascal squared second; m: meters

Exposure Estimates

As described above, for acoustic stressors, we considered exposure estimates from the Phase III NAEMO model at two output points for marine mammals (i.e., unprocessed and final take estimates). The Navy provided NMFS with the total estimated number of unprocessed exposures from acoustic and explosive stressors (i.e., estimates were not broken out between the different acoustic stressors and explosives). This information is presented in Table 78 below. The NAEMO output estimates that ESA-listed marine mammals will be exposed to these stressors throughout the year. Table 78 provides the maximum annual number of unprocessed exposures for each marine mammal species considered in this opinion. The estimates include exposures from both annual and non-annual training and testing activities. In most years, the number of exposures would be less than listed below as some activities are not conducted every year but all potential acoustic exposures from sonar and explosives were included to generate conservative estimates of impacts to marine mammals.

Table 78. Unprocessed exposure estimates of ESA-listed marine mammals to acoustic and explosive stressors.

Species	Training/Testing	Unprocessed exposures			
		> 121 dB	> 163 dB	>181 dB	> 205 dB
Blue whale	Training	753	68	17	<1
	Testing	551	64	32	2
	TOTAL	1,304	131	48	2
Bryde's whale – Gulf of Mexico subspecies	Training	74	18	5	0
	Testing	1,995	307	110	9
	TOTAL	2,069	325	115	9
Fin whale	Training	40,938	7,633	1,956	32
	Testing	83,418	10,147	3,903	353
	TOTAL	124,355	17,780	5,858	385
North Atlantic right whale	Training	5,380	1,875	714	11
	Testing	6,808	995	337	13
	TOTAL	12,188	2,870	1,051	24
Sei whale	Training	7,058	933	196	1
	Testing	11,436	1404	532	51
	TOTAL	18,495	2,337	727	53
Sperm whale	Training	314,880	22,145	2,541	34
	Testing	314,773	34,315	15,010	1,501
	TOTAL	629,653	56,460	17,550	1,534

As described previously in the introduction to this section, only a subset of the unprocessed exposures presented in Table 78 are expected to result in PTS, TTS, or a significant behavioral response (i.e., take as defined under the ESA), based on the criteria and thresholds described in the technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017b). Table 79 lists the marine mammal take estimates for Navy training and testing activities using sonar and other transducers conducted annually in the action area. Only the most severe impact expected (i.e., PTS>TTS>behavioral) is quantified in this table. Instances of PTS or TTS are expected to have associated behavioral responses.

Table 79. Estimated ESA-listed marine mammal impacts (i.e., PTS, TTS, or significant behavioral disruption) per year from sonar and other transducers during training and testing activities.

Species	Training/Testing	PTS	TTS	Behavioral
Blue whale	Training	0	18	8
	Testing	0	16	4
	TOTAL	0	34	12
Bryde's whale – Gulf of Mexico subspecies	Training	0	0	0
	Testing	0	27	24
	TOTAL	0	27	24
Fin whale	Training	0	933	533
	Testing	2	2,434	1,183
	TOTAL	2	3,367	1,716
North Atlantic right whale	Training	0	121	116
	Testing	0	127	87
	TOTAL	0	248	203
Sei whale	Training	0	202	88
	Testing	0	320	157
	TOTAL	0	522	245
Sperm whale	Training	0	326	13,777
	Testing	0	350	12,029
	TOTAL	0	676	25,806

Table 80 through Table 90 break these estimates of PTS, TTS, and significant behavioral disruption down by location within the action area and activity category. There is a potential for impacts to occur anywhere within the action area where sound from sonar and ESA-listed marine mammal species overlap. However, only regions or activity categories where 0.5 percent or greater of the impacts are estimated to occur are presented in the tables.

Table 80. Estimates of blue whale PTS, TTS, and significant behavioral disruption from sonar and other transducers during training.

Region	Activity Category	PTS	TTS	Behavioral
Groton, CT	Nav and object detection	0	1	0
VACAPES RC	ASW Unit Level Training	0	1	1
Cherry Point RC	Major Training Events	0	1	0
Jacksonville RC	ASW Unit Level Training	0	4	3
	ASW Coordinated/Integ Training	0	1	0
	Major Training Events	0	6	1

Notes: ASW = Anti-submarine warfare; RC = Range Complex

Table 81. Blue whale take estimates from sonar and other transducers during testing.

Region	Activity Category	PTS	TTS	Behavioral
Northeast RCs	Acoustic and Oceanographic Res	0	2	1
VACAPES RC	ASW	0	4	1
Jacksonville RC	ASW	0	7	1
	Vessel Evaluation	0	1	0

Table 82. North Atlantic right whale take estimates from sonar and other transducers during training.

Region	Activity Category	PTS	TTS	Behavioral
Northeast RCs	ASW sonar maintenance	0	1	0
Groton, CT	Nav and object detection	0	34	9
VACAPES RC	ASW sonar maintenance	0	5	1
	ASW unit level training	0	0	1
	Nav and object detection	0	0	1
	Major training events	0	3	1
Cherry Point RC	ASW sonar maintenance	0	7	2
	ASW unit level training	0	1	0
	ASW coordinated/integrated training	0	2	0
	Major training events	0	7	1
Jacksonville, RC	ASW sonar maintenance	0	10	2
	ASW unit level training	0	2	1
	Major training events	0	1	0
Savannah, GA	Mine warfare	0	2	4
Kings Bay, GA	Mine warfare	0	1	4
	Nav and object detection	0	5	2
Mayport, FL	Mine warfare	0	2	5
	Nav and object detection	0	19	75
Port Canaveral, FL	Mine warfare	0	0	1
	Nav and object detection	0	15	5

Table 83. North Atlantic right whale take estimates from sonar and other transducers during testing.

Region	Activity Category	PTS	TTS	Behavioral
Northeast RCs	Acoustic and oceanographic research	0	55	31
	ASW	0	24	22
	Vessel evaluation	0	1	3
NUWC Newport Testing Range	ASW	0	1	1
	Other testing activities	0	2	3
VACAPES RC	ASW	0	2	1
	Vessel evaluation	0	1	0
Cherry Point RC	ASW	0	6	0
Jacksonville RC	ASW	0	15	6
	Vessel evaluation	0	12	1
SFOMF	Vessel evaluation	0	0	1
	Other testing activities	0	4	12

Table 84. Bryde's whale Gulf of Mexico subspecies take estimates from sonar and other transducers during testing.

Region	Activity Category	PTS	TTS	Behavioral
Gulf of Mexico RC	Acoustic and oceanographic res	0	2	3
	ASW	0	4	4
	Vessel evaluation	0	1	1
	Mine warfare	0	20	8
NSWC Panama City Testing Range	Mine warfare	0	0	1
	Other testing activities	0	0	1

Table 85. Fin whale take estimates from sonar and other transducers during training.

Region	Activity Category	PTS	TTS	Behavioral
Northeast RCs	Mine warfare	0	0	1
	ASW sonar maintenance	0	56	42
	ASW unit level training	0	35	39
Groton, CT	ASW sonar maintenance	0	1	0
	Nav and object detection	0	91	16
VACAPES RC	ASW sonar maintenance	0	194	141
	ASW unit level training	0	263	185
	Nav and object detection	0	0	1
	ASW coordinated/integrated training	0	24	12
	Major training events	0	155	40
Cherry Point RC	ASW sonar maintenance	0	7	5
	ASW unit level training	0	2	2
	ASW coordinated/integrated training	0	5	1
	Major training events	0	29	2
Jacksonville, RC	ASW sonar maintenance	0	5	3
	ASW unit level training	0	20	12
	ASW coordinated/integrated training	0	3	0
	Major training events	0	26	10
Mayport, FL	Nav and object detection	0	0	1

Table 86. Fin whale take estimates from sonar and other transducers during testing.

Region	Activity Category	PTS	TTS	Behavioral
Northeast RCs	Acoustic and oceanographic research	2	1,475	355
	ASW	0	104	197
	Vessel evaluation	0	2	13
NUWC Newport Testing Range	ASW	0	32	27
	Other testing activities	0	15	31
VACAPES RC	Acoustic and oceanographic research	0	85	134
	ASW	0	590	376
	Vessel evaluation	0	68	25
	Mine warfare	0	0	1
Cherry Point RC	ASW	0	12	3
Jacksonville RC	Acoustic and oceanographic research	0	0	2
	ASW	0	36	9
	Vessel evaluation	0	7	2
SFOMF	Other testing activities	0	1	4
Gulf of Mexico RC	Mine warfare	0	2	0
NSWC Panama City Testing Range	Other testing activities	0	0	2

Table 87. Sei whale take estimates from sonar and other transducers during training.

Region	Activity Category	PTS	TTS	Behavioral
Northeast RCs	ASW sonar maintenance	0	11	6
	ASW unit level training	0	7	6
Groton, CT	Nav and object detection	0	3	1
VACAPES RC	ASW sonar maintenance	0	20	14
	ASW unit level training	0	47	26
	ASW coordinated/integrated training	0	6	2
	Major training events	0	28	5
Cherry Point RC	ASW unit level training	0	2	1
	ASW coordinated/integrated training	0	3	0
	Major training events	0	7	1
Jacksonville RC	ASW unit level training	0	13	10
	ASW coordinated/integrated training	0	6	0
	Major training events	0	30	4
Mayport, FL	ASW coordinated/integrated training	0	0	1

Table 88. Sei whale take estimates from sonar and other transducers during testing.

Region	Activity Category	PTS	TTS	Behavioral
Northeast RCs	Acoustic and oceanographic research	0	161	49
	ASW	0	17	28
	Vessel evaluation	0	0	2
NUWC Newport Testing Range	ASW	0	6	5
	Other testing activities	0	3	3
VACAPES RC	Acoustic and oceanographic research	0	7	12
	ASW	0	78	47
	Vessel evaluation	0	7	3
Cherry Point RC	ASW	0	8	1
Jacksonville, RC	ASW	0	30	3
	Vessel evaluation	0	3	1
SFOMF	Other testing activities	0	1	1

Table 89. Sperm whale take estimates from sonar and other transducers during training.

Region	Activity Category	PTS	TTS	Behavioral
Northeast RCs	ASW sonar maintenance	0	1	318
	ASW unit level training	0	1	743
Groton, CT	ASW sonar maintenance	0	1	1
	Nav and object detection	0	3	28
VACAPES RC	Mine warfare	0	0	54
	ASW sonar maintenance	0	8	1,464
	ASW unit level training	0	60	3,892
	ASW coordinated/integrated training	0	27	1,088
	Major training events	0	136	1,342
Cherry Point RC	Mine warfare	0	0	3
	ASW sonar maintenance	0	2	368
	ASW unit level training	0	28	371
	ASW coordinated/integrated training	0	16	686
	Major training events	0	16	354
Jacksonville, RC	ASW sonar maintenance	0	0	12
	ASW unit level training	0	5	223
	ASW coordinated/integrated training	0	0	53
	Major training events	0	10	382
Gulf of Mexico RC	ASW unit level training	0	0	22

Table 90. Sperm whale take estimates from sonar and other transducers during testing.

Region	Activity Category	PTS	TTS	Behavioral
Northeast RCs	Acoustic and oceanographic research	0	6	1,231
	ASW	0	3	840
	Vessel evaluation	0	0	45
NUWC Newport Testing Range	ASW	0	0	7
	Other testing activities	0	0	7
VACAPES RC	Acoustic and oceanographic research	0	2	453
	ASW	0	260	6,553
	Vessel evaluation	0	9	477
	Mine warfare	0	0	12
Cherry Point RC	ASW	0	29	728
Jacksonville, RC	Acoustic and oceanographic research	0	0	4
	ASW	0	10	105
	Vessel evaluation	0	0	13
	Mine warfare	0	0	16
	Other testing activities	0	0	13
SFOMF	ASW	0	0	1
	Vessel evaluation	0	0	4
	Mine warfare	0	0	2
	Other testing activities	0	6	58
Gulf of Mexico RC	Acoustic and oceanographic research	0	15	276
	ASW	0	2	312
	Vessel evaluation	0	0	59
	Mine warfare	0	4	308
Key West	ASW	0	0	314
	Other testing activities	0	0	13
NSWC Panama City Testing Range	Mine warfare	0	0	21
	Other testing activities	0	2	25

For North Atlantic right whale take estimated to occur in the Northeast Range Complexes and Jacksonville Range Complex, the Navy also provided more specific information on where within these range complexes the takes are expected to occur and from what type of activity. Given the status of North Atlantic right whales (See Section 7.2.4), this level of granularity was useful in our evaluation of the potential consequences of these instances of take to individual North Atlantic right whales (see sonar risk analysis). For the southeast, the Navy provided information on which takes are expected to occur within versus outside of the Southeast North Atlantic Right Whale Mitigation Area (Table 91). As described previously, the Southeast North Atlantic Right Whale Mitigation Area proposed by the Navy encompasses some, but not all, of the area designated as critical habitat for calving for that species. For the northeast, the modeling did not indicate any takes would occur inside critical habitat designated for that species in the Gulf of Maine, but some takes are anticipated outside of critical habitat within the Northeast Range Complexes (Table 92). The Navy's Northeast North Atlantic Right Whale Mitigation Area encompasses all of the critical habitat designated for this species in the northeast.

Table 91. Estimated instances of North Atlantic right whale TTS and behavioral harassment takes within and outside (i.e., in Jacksonville Range Complex) the Navy's Southeast North Atlantic Right Whale Mitigation Area off the coast of Florida and Georgia.

Outside or Inside Southeast NARW Mitigation Area	Activity	TTS and Behavioral takes	Duration of sonar/activity
Outside	At-sea sonar testing	7	4-6 hrs per day, up to 11 days
	USW testing	13	4-8 hrs per day, up to 10 days
	Signature analysis testing	8	4-6 hrs
	Acoustic component test	7	4-6 hrs
	COMPTUEX	1	8-12 hrs/day, 10 days
	Surface ship maintenance	12	<1 hr
Inside	Civilian Port Defense[1]	17	1-4 hrs/day, 2-4 days
	Sub Navigation – Kings Bay	6	0.5 hrs
	Sub Navigation – Jacksonville RC	11	0.5 hrs
	Sub Navigation – Port Canaveral	20	0.5 hrs
	Ship object detection	82	0.5 hrs

[1]*All sonar used operates at greater than 10 kHz.*

Table 92. Estimated instances of North Atlantic right whale TTS and behavioral harassment in Northeast Range Complexes outside of foraging critical habitat designated for North Atlantic right whales in the Gulf of Maine.

Activity	TTS and Behavioral takes	Duration of sonar/activity
Acoustic research	69	4-8 hrs/day, up to 14 days
Emergent Mine Counter Measure Test	16	2-4 hrs/day, up to 14 days
Sub Navigation	43	0.5 to 1 hrs
Torpedo testing (non-explosive)	33	Up to 2 hrs/day, up to 14 days

As stated previously, the take estimates presented above and analyzed in this opinion are based on Navy modeling, as described in Section 2.2. The modeling conclusions from the Navy's analysis represent the best available data on exposure of marine mammals to acoustic stressors from the proposed action, but there is uncertainty. When the Navy's modeling is conducted, proposed activities are modeled as occurring in certain locations based on the Navy's assessment of where these activities are most likely to occur in the future. For example, Navy modeling indicated that only one take of North Atlantic right whales from major training exercises (MTEs) is anticipated to occur annually for the duration of the proposed MMPA rule in or in close proximity to critical habitat in the southeast (Table 91). MTEs use multiple sonar platforms and last for several days, so have the potential to result in many instances of take of marine mammals, including North Atlantic right whales, depending on where and when they occur. That only one North Atlantic right whale take in or near critical habitat was modeled annually for MTEs suggests that most of the MTE activity is expected to occur well offshore of critical habitat (i.e., where North Atlantic right whales are not expected to occur) or north of designated critical habitat. The Navy will submit annual reports to NMFS that provide information on whether or not training and testing activities were implemented as was assumed during the modeling exercise.

9.2.1.1.3 Response Analysis

Section 9.2.1.1.1 described the range of potential responses of ESA-listed marine mammals to sonar and other transducers associated with the proposed action. Given the above estimated exposure of ESA-listed marine mammals to sonar and other transducers associated with the proposed action, in this section we describe the likely responses of these species to this exposure. This includes behavioral responses and sound-induced hearing loss (i.e., TTS and PTS), as well as other possible responses (e.g., stress) that cetaceans may exhibit to exposure to sound fields from sonar and other transducers. Our aim with this response analysis is to assess the potential responses that might reduce the fitness of individual ESA-listed marine mammals. In doing so, we consider and weigh evidence of adverse consequences, as well as evidence suggesting the absence of such consequences. In cases where data on the responses of the ESA-listed species considered in this opinion to sonar and other transducers are not available, we rely on data from other closely-related species. In addition, we rely on information on the responses of ESA-listed species, as well as other related species, to anthropogenic sound sources other than military sonars (e.g., seismic air guns). We recognize that there can be species and sound-specific responses, and even within species, not all individual animals are likely to respond to all sounds in the same way. Nonetheless, by examining the range of responses that ESA-listed and other related species exhibit to anthropogenic sounds, we incorporate uncertainty in our analysis that stems from intra- and inter-species response heterogeneity and make use of the best available science.

Hearing Threshold Shifts

Whether or not a hearing threshold shift will impact an individual animal's fitness depends on the duration, frequency, and magnitude of the shift. The frequencies affected by hearing loss will vary depending on the frequency of the fatiguing noise, with frequencies at and above the noise frequency most strongly affected. As described previously, the Navy uses sonars operating at a wide range of frequencies (i.e., from low frequency sources to extremely high frequency sources). Cetaceans that experience PTS or TTS from sonar sounds are likely to have reduced ability to detect biologically important sounds around the frequency band of the sonar until their hearing recovers. Some instances of hearing threshold shift are likely to occur at frequencies utilized by animals for acoustic cues. For example, during the period that a mysticete has hearing loss, social calls from conspecifics could be more difficult to detect or interpret if they fell in the octave band of the sonar frequency. Killer whales are a primary predator of mysticetes. Some hearing loss could make killer whale calls more difficult to detect until hearing recovers. It is unclear how or if mysticetes use sound for finding prey or feeding; therefore, it is unknown whether hearing loss would affect a mysticete's ability to locate prey or rate of feeding.

The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to several days to fully recover, depending on the magnitude of the initial threshold shift. Instances of TTS resulting from Navy training and testing activities are expected to be minor to moderate (i.e., less than 20 dB of TTS directly after the exposure) and would recover within a matter of minutes to hours. Though there is uncertainty, this relatively short recovery time is supported by available information from the literature (e.g., Finneran 2015). Exposures resulting in TTS are expected to be short term and of relatively low received level because of animal avoidance and the transient nature of most Navy sonar sources. Behavioral research (See Section 9.2.1.1.1.5) indicates that mysticetes most often will avoid sound sources at levels that would cause hearing loss, particularly more severe instances of TTS or PTS. Additionally, most Navy sonar sources are not stationary, minimizing the likelihood that an animal would remain in close proximity to the source for periods of time that could result in more severe instances of TTS (i.e., because marine mammals generally avoid loud sources of anthropogenic sound). Despite these factors that are expected to minimize the severity of TTS, we assume that some (See Table 79 and Table 80 for estimates) blue, Bryde's, fin, North Atlantic right, sei, and sperm whales will experience TTS as the result of being exposed to sonar and other transducers from Navy training and testing activities. As is the nature of TTS, such effects would be temporary and exposed individuals' hearing is expected to return to normal within minutes to days.

Also important to consider is the potential for repeat instances of TTS due to exposure to Navy sonar. In some exposure scenarios, it is possible that a particular animal will be exposed to sonar resulting in TTS and then, prior to being fully recovered, will be exposed again at a level resulting in TTS. Experimental studies have not explored such scenarios, so there is uncertainty as to how long recovery would take in these particular cases. It is possible that repeat instances of TTS could result in PTS. This has been shown in terrestrial animals (e.g., Kujawa and Liberman 2009; Lin et al. 2011a), and in one case, marine mammals as well (Kastak et al. 2008).

Behavioral responses

The Navy uses a behavioral response function to quantify the number of behavioral responses that could qualify as a significant behavioral disruption. Under the behavioral response function, a wide range of behavioral reactions may qualify as significant, including but not limited to avoidance of the sound source, temporary changes in vocalizations or dive patterns, temporary avoidance of an area, or temporary disruption of feeding, migrating, or reproductive behaviors. The estimates calculated using the behavioral response functions (See Section 2.2.1.2.2) do not differentiate between the different types of potential reactions nor the significance of those potential reactions. These estimates also do not provide information regarding the potential fitness or other biological consequences of the reactions on the affected individuals. Therefore, our analysis considers the available scientific evidence to determine the likely nature of modeled behavioral responses and potential fitness consequences for affected individuals.

The range of potential behavioral responses due to sonar exposure is presented in Section 9.2.1.1.1.5. There are two general categories of information available regarding the likely responses of marine mammals to sonar exposure: 1) information from controlled exposure experiments, and 2) information from opportunistic observations during the operation of real world sonar. This research shows that cetacean response to acoustic disturbance varies, depending on the characteristics of the sound source, the animal's experience with the sound source, and their behavioral state (e.g., migrating, breeding, feeding) at the time of the exposure.

As presented in a review by Southall et al. (2016), common responses to sonar during controlled exposure experiments include avoidance of the area of sonar exposure, cessation or modification of vocal behavior, and cessation of foraging. More minor reactions have also been observed including alerting to the sound source and startle responses. Southall et al. (2016) found that many, but not all responses of cetaceans to sonar observed so far have been relatively mild and/or brief. For example, both Goldbogen et al. (2013a) and Melcon et al. (2012) indicated that behavioral responses to simulated or operational sonar were temporary, with whales resuming normal behavior quickly after the cessation of sound exposure. Further, responses were discernible for whales in certain behavioral states (i.e., deep feeding), but not in others (i.e., surface feeding). In summarizing the response of blue whales to mid-frequency sonar, Goldbogen et al. (2013a) states, "We emphasize that elicitation of the response is complex, dependent on a suite of contextual (e.g., behavioral state) and sound exposure factors (e.g., maximum received level), and typically involves temporary avoidance responses that appear to abate quickly after sound exposure." If individual ESA-listed cetaceans briefly respond to underwater sound from Navy training and testing (e.g., by slightly changing their behavior or temporarily relocating a short distance), the effects can be considered a behavioral response, but are unlikely to be significant to the animal unless that interruption is repeated many times. However, Southall et al. (2016) noted the short-term experiments designed to elicit behavioral responses from cetaceans due to sonar exposure were deliberately designed not to harm the affected animals.

Melcon et al. (2012) reported that baleen whales (i.e., blue whales) exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low frequency calls (D calls) usually associated with feeding behavior. However, they were unable to determine if suppression of D calls reflected a change in their feeding performance or abandonment of foraging behavior and indicated that implications of the documented responses are unknown. Goldbogen et al. (2013a) speculated that if the documented temporary behavioral responses interrupted feeding behavior, this could have impacts on individual fitness and eventually, population health. However, for this to be true, we would have to assume that an individual whale could not compensate for this lost feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would likely still be available in the environment in most cases following the cessation of acoustic exposure (i.e., sonar could cause scattering of prey, but would not be expected to injure or kill it). There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, we do not anticipate this movement to be consequential to the animal over the long term (Southall et al. 2007a).

While the Navy implements a series of mitigation measures to minimize high level sonar exposures during training and testing events, the responses of animals to real world Navy sonar could vary from the small scale, short-term controlled exposure experiments reviewed by Southall et al. (2016). Most of the studies reviewed by Southall et al. (2016) involved a single platform transmitting sonar or another sound source for a short period of time. This is in contrast to what would be expected during some Navy activities (e.g., MTEs) involving sonar where multiple vessels are operating concurrently in close proximity, during an exercise that lasts for an extended period of time (i.e., multiple days to weeks). The response of an animal to an initial exposure during such an event may be different than what could be expected if an animal is exposed multiple times or for a long period of time during an event. Additionally, while these studies can implement controls for some variables (e.g., the distance and movement of the source), they also introduce additional variables that do not normally occur in a real Navy training or testing activity, including the tagging of whales, intentionally following the tagged animals with multiple vessels, and continually approaching the animal to create a dose escalation.

Because of the limitations associated with controlled exposure experiments, it is also important to consider studies that opportunistically observed the response of cetaceans to real world Navy sonar. Passive acoustic monitoring and visual observational behavioral response studies have been conducted on Navy ranges, taking advantage of the existing seafloor hydrophones and real testing and training activity and associated sources to assess behavioral responses (Deakos and Richlen 2015; Henderson et al. 2016; Manzano-Roth et al. 2016; Martin et al. 2015; Mccarthy et al. 2011; Mobley and Deakos 2015; Moretti et al. 2014; Tyack et al. 2011b). Collectively, these studies have indicated that responses vary, and include avoidance of the area of sonar exposure, cessation or modification of vocal behavior, changes in dive behavior, and cessation of foraging. In addition, extensive aerial, visual, and acoustic monitoring is conducted before, during and after training events to watch for behavioral responses during training and look for injured or stranded animals after training (Campbell et al. 2010; Farak et al. 2011; HDR 2011; Navy 2011b; Navy 2013a; Navy 2014b; Navy 2015; Norris et al. 2012; Smultea and Mobley 2009; Smultea et al. 2009; Trickey et al. 2015). During all of these monitoring efforts, only a few behavioral responses have been observed, and no injured or dead animal was observed that was directly related to a training event (some dead animals were observed, but typically before the event, or appeared to have been deceased prior to the event; Smultea et al. 2011). However, it should be noted that passive acoustic studies are limited to observations of vocally-active marine mammals and visual studies are limited to what can be observed at the surface. These study types do have the benefit of occurring in the absence of some of the added contextual variables in the controlled exposure studies.

The limitations of opportunistic observations (e.g., limited to observations of vocally-active marine mammals or animals at the surface, limited ability to monitor animal activity long-term, limited ability to control other variable which could impact animal behavior [e.g., prey distribution]) result in some uncertainty as to the likely responses of ESA-listed cetaceans due to sonar exposure. Forney et al. (2017) noted that species that respond to noise (e.g., from military sonars) by avoiding an area are unlikely to be observed using traditional methods (e.g., lookouts or passive acoustic monitoring) because animals react at distances far greater than the detection range of these methods. They suggest that individuals that are observed must be considered relatively tolerant of anthropogenic noise.

In summary, the available information indicates a range of behavioral responses to sonar may occur, but most responses are expected to be brief, with the animal returning to baseline behavior shortly after the exposure is over. However, as noted by Forney et al. (2017), there is uncertainty due to the limitations of observing marine mammal response to sonar in the wild.

Masking (auditory interference)

The potential effects of masking were described in Section 9.2.1.1.1.4. Some limited masking could occur due to the Navy's use of sonar and other transducers when animals are in close enough proximity. That is, if an animal is close enough to the source to experience, PTS, TTS, or a significant behavioral disruption, we anticipate some masking could occur. As stated previously, masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking from noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, and acoustically-mediated cooperative behaviors such as foraging or reproductive activities.

Because traditional military sonars typically have low duty cycles, the effects of such masking are expected to be limited. The typical duty cycle with most tactical anti-submarine warfare is about once per minute with most active sonar pulses lasting no more than a few seconds (Navy 2013b). This indicates biologically-relevant sounds for individuals in close proximity would only be masked intermittently for a short time.

Newer high duty cycle or continuous active sonars have more potential to mask vocalizations, particularly for sperm whales, but as explained below, these effects would only happen close to the source. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, high frequency acoustic sources such as pingers that operate at higher repetition, also operate at lower source levels. While the lower source levels of these systems limit the range of impact compared to more traditional systems, animals close to the sonar source could experience masking on a much longer time scale than those exposed to traditional sonars. However, this effect would only occur if the animals were to remain in close proximity to the source.

Non-auditory physical or physiological responses

The available research on the potential for sonar or other sources of anthropogenic noise to result in physiological responses (e.g., stress) is described in Section 9.2.1.1.1.3. Relatively little information exists on the linkage between anthropogenic sound exposure and stress in marine mammals, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). However, increased stress has been documented as a result of both acute (e.g., Romano et al. 2004) and chronic (e.g., Rolland et al. 2012) anthropogenic noise. As described previously, though there are unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, it is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

9.2.1.1.4 Risk Analysis

In the exposure and response analysis, we established that a range of impacts including temporary threshold shift, behavioral response, and stress are likely occur due to exposure to Navy sonar during training and testing events. In this, section we assess the likely consequences of the responses to the individuals that have been exposed. We determined that the potential effects of masking from sonar are limited because of the duty cycles of most military sonars and the transient nature of sonar use, so we have concluded that there is little to no risk associated with exposure and response to masking. In order to consider the potential consequences of temporary hearing impacts, behavioral response, and stress to affected animals, we must also consider the context of the exposure and response scenario including the following: 1) the duration of the exposure and associated response, 2) whether or not repeated exposures would be expected, 3) the behavioral state of the animal at the time of the response, and 4) the health of the animal at the time of the response.

Since marine mammals depend on acoustic cues for vital biological functions (e.g., orientation, communication, finding prey, avoiding predators), fitness consequences could occur to individual animals from hearing threshold shifts that last for a long time, occur at a frequency utilized by the animal for acoustic cues, and are of a profound magnitude. A hearing threshold shift of limited duration, occurring in a frequency range that does not coincide with that used for vocalization or recognition of important acoustic cues would likely have no effect on an animal's fitness. Based on the literature cited in Section 9.2.1.1.1 and the response analysis, we expect instances of TTS from Navy sonar to be short-term and of relatively low severity because of animal avoidance and the transient nature of most Navy sonar sources.

The literature described in the response analysis and in Section 9.2.1.1.16.1.5 indicate that most behavioral responses that have been observed to sonar exposure are of mild to moderate severity, often lasting for the duration of the exposure. Some more severe reactions have been observed, but these have mostly been in cetacean species known to be particularly sensitive to acoustic disturbance (e.g., beaked whales; Southall et al. 2016), which are not listed under the ESA. Based on information available to date, the cetacean species considered in this opinion are not thought to be particularly sensitive to acoustic disturbance. However, it is worth noting that the controlled exposure experiments reviewed by Southall et al. (2016) were deliberately designed to demonstrate the onset of response and not to produce adverse or permanent effects. Additionally, the limitations of opportunistic observations (e.g., limited to observations of vocally-active marine mammals or animals at the surface, limited ability to monitor animal activity long-term, limited ability to control other variable which could impact animal behavior [e.g., prey distribution]) result in some uncertainty as to the severity and duration of likely responses of ESA-listed cetaceans due to sonar exposure. Forney et al. (2017) noted that species that respond to noise (e.g., from military sonars) by avoiding an area are unlikely to be observed using traditional methods (e.g., lookouts or passive acoustic monitoring) because animals react at distances far greater than the detection range of these methods. They suggest that individuals that are observed must be considered relatively tolerant of anthropogenic noise.

The duration and magnitude of the proposed activity is important to consider in determining the likely severity, duration, and potential consequences of exposure and associated response to Navy sonar. As noted in Southall et al. (2007a), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. As described further in Section 3.3 (e.g., Table 12), several categories of training exercises (e.g., MTEs such as Composite Training Unit Exercises) are expected to result in hundreds of hours of sonar activity involving multiple platforms (i.e., surface vessels, submarines, and aircraft) utilizing sonar. These exercises range in duration from two days to over ten, and therefore have the potential to result in sustained and/or repeat exposure. However, while MTEs may have a longer duration, they are not concentrated in small geographic areas over that time period. MTEs use thousands to tens of thousands of square miles of ocean space during the course of the event. With the exception of Elevated Causeway construction (discussed in Section 9.1.1.1.5), there is no Navy activity in the proposed action that is both long in duration (more than a day) and concentrated in the same location (e.g., within a few square miles), so there is a low likelihood that animals and Navy activities will co-occur for extended periods of time or repetitively over the duration of an activity (83 FR 15117).

While it is difficult to predict exactly what a marine mammal may be doing at the time of exposure, we can make some predictions based on time of year and the location of the animal at the time of exposure, where such information is available. Halpin et al. (2015) merged existing published and unpublished information on marine mammals along the United States east coast to identify BIAs for some of the marine mammal species considered in this opinion. Many of these BIAs are identified by the activity that a particular species is likely to be engaged in within these areas (e.g., foraging, migrating, reproducing), and represent the best available information about the activities in which cetaceans are likely to be engaged at a certain time and place (Halpin et al. 2015). If a behavioral response were to occur in these BIAs, we can make reasonable predictions as to the particular activity of an animal at the time of exposure. For example, for North Atlantic right whales, Halpin et al. (2015)identified BIAs along the east coast for foraging, migrating, and calving. Critical habitat for calving in the southeast and foraging in the northeast have also been designated for North Atlantic right whales. If a behavioral response occurred in the foraging BIA or foraging critical habitat, the expectation is that feeding would be interrupted. If a behavioral response were to occur in the calving area, the expectation is these activities (e.g., nursing young, resting) would be disrupted. If a behavioral response were to occur in the migration BIA, the animal's migration would be disrupted. Similar logic would apply for exposures occurring along the east coast in the sei whale feeding BIA and fin whale feeding BIAs.

It's important to note that the BIAs identified by Halpin et al. (2015) only consist of a portion of the range of habitats utilized by the species considered in this opinion in the action area. For example, activities such as foraging are expected to occur in areas outside of the identified BIAs as well. Just because an exposure and associated response may not occur in an identified BIA, does not mean important activities will not be disrupted because of those exposures. Additionally, Halpin et al. (2015) were not able to identify BIA's for some activities (e.g., calving) for some species due to lack of available information. Therefore, the BIAs identified by Halpin et al. (2015) can help predict the activities of some animals in certain situations along the east coast portion of the action area, but not all activities or species throughout the action area.

Also important to consider is an animal's prior experience with a sound source. The majority of animals exposed to sound from Navy training and testing activities have likely been exposed to such sources previously as these activities have been occurring in the action area for decades. Harris et al. (2017a) suggested that processes such as habituation, sensitization, or learning from past encounters may lead to stronger or weaker reactions than those of a naïve animal. For example, Baird et al. (2017) found no large-scale avoidance by false killer whales of areas with relatively high mid-frequency active sonar use in the Pacific Missile Range Facility in Hawaii. The authors suggested that since sonar had been used at Pacific Missile Range Facility for over 30 years, it was likely that animals in this area had been exposed to sonar multiple times on previous occasions. The authors suggested that more naïve populations may be more likely to exhibit avoidance responses if exposed to sonar.

When considering the potential consequences of exposure and response to Navy sonar, we must also take into account the health of the individual animal affected. Individuals that are in good health, with sufficient energy reserves, are likely to be much more resilient when faced with long-term or repeated disturbance than an animal in poor condition. As described in Harris et al. (2017a), one approach to understanding the potential importance of a behavioral response is to consider an animal's energy budget. Marine mammal behavioral research has indicated that many species including humpback whales (Silve et al. 2016), blue whales (Goldbogen et al. 2013a), and sperm whales (Isojunno et al. 2016) may disrupt foraging when exposed to anthropogenic noise. If the animals are not able to make up for lost foraging opportunities due to such exposure, this could have consequences on the affected animal's available energy supply. For individuals in good health, with sufficient energy reserves, such a reduction could likely be compensated for at a later time, provided the animal is not subject to sustained disruption. However, for individuals in a compromised state, a reduction in available energy has a higher likelihood of being consequential, depending on the duration of the disruption (i.e., long duration disruptions would have a higher likelihood of being consequential).

Quantifying the fitness consequences of sub-lethal impacts is exceedingly difficult for marine mammals because of the limitations of studying these species (e.g., due to the costs and logistical challenges of studying animals that spend the majority of time underwater). Harris et al. (2017a) summarized the research efforts conducted to date that have attempted to understand the ways in which behavioral responses may result in long-term consequences to individuals and populations. Efforts have been made to try and quantify the potential consequences of such responses, and frameworks have been developed for this assessment (e.g., Population Consequences of Disturbance). However, models that have been developed to date to address this question require many input parameters and, for most species, there are insufficient data for parameterization (Harris et al. 2017a). A key factor limitation in these models is that we often do not have empirical data to link sub-lethal behavioral responses to effects on animal vital rates.

Behavioral responses may impact health through a variety of different mechanisms, but most Population Consequences of Disturbance models focus on how such responses affect an animal's energy budget (Costa et al. 2016c; Farmer et al. 2018; King et al. 2015b; NAS 2017; New et al. 2014; Villegas-Amtmann et al. 2017). Responses that relate to foraging behavior, such as those that may indicate reduced foraging efficiency (Miller et al. 2009) or involve the complete cessation of foraging, may result in an energetic loss to animals. Other behavioral responses, such as avoidance, may have energetic costs associated with traveling (NAS 2017). Important in considering whether or not energetic losses, whether due to reduced foraging or increased traveling, will affect an individual's fitness is considering the duration of exposure and associated response. Nearly all studies and experts agree that infrequent exposures of a single day or less are unlikely to impact an individual's overall energy budget and that long duration and repetitive disruptions would be necessary to result in consequential impacts on an animal (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015b; NAS 2017; New et al. 2014; Southall et al. 2007d; Villegas-Amtmann et al. 2015).

We also recognize that aside from affecting health via an energetic cost, a behavioral response could result in more direct impacts to health and/or fitness. For example, if a whale hears Navy sonar and avoids the area, this may cause it to travel to an area with other threats such as vessel traffic or fishing gear. However, we find such possibilities (i.e., that a behavioral response would lead directly to a ship strike) to be extremely remote and not reasonably certain to occur, and so focus our risk analysis on the energetic costs associated with a behavioral response.

To summarize, we would expect many exposures and potential responses of ESA-listed cetaceans to sonar and other transducers to have little effect on the exposed animals. Based on the controlled exposure experiments and opportunistic research presented above, responses are expected to be short term, with the animal returning to normal behavior patterns shortly after the exposure is over. However, there is some uncertainty due to the limitations of the controlled exposure experiments and observational studies used to inform our analysis. Additionally, Southall et al. (2016) suggested that even minor, sub-lethal behavioral changes may still have significant energetic and physiological consequences given sustained or repeated exposure. Quantifying the fitness consequences of sub-lethal impacts from acoustic stressors is exceedingly difficult for marine mammals and we do not currently have data to conduct a quantitative analysis on the likely consequences of such sub-lethal impacts. While we are unable to conduct a quantitative analysis on how sub-lethal behavioral effects and temporary hearing impacts may impact animal vital rates (and therefore fitness), based on the best available information, we expect an increased likelihood of consequential effects when exposures and associated effects are long-term and repeated, occur in locations where the animals are conducting critical activities, and when the animal affected is in a compromised state.

For most of the cetaceans that will be impacted by Navy sonar activities in the action area (i.e., blue whale, fin whale, sei whale, and sperm whale), we do not have information to suggest affected animals are likely to be in a compromised state at the time of exposure. During exposure, affected animals may be engaged in any number of activities including, but not limited to, migration, foraging, or resting. If blue, fin, sei, or sperm whales exhibited a behavioral response to Navy sonar, these activities would be disrupted and it may pose some energetic cost. However, as noted previously, responses to Navy sonar are anticipated to be short term and instances of hearing impairment are expected to be mild or moderate. Based on best available information that indicates whales resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013a; Melcon et al. 2012), we anticipate that exposed animals will be able to return normal behavioral patterns after this short duration activity ceases. Goldbogen et al. (2013a) suggested that if the documented temporary behavioral responses interrupted feeding behavior, this could have impacts on individual fitness and eventually, population health. However, for this to be true, we would have to assume that an individual whale could not compensate for this lost feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would still be available in the environment following the cessation of acoustic exposure (i.e., sonar could cause scattering of prey, but would not be expected to injure or kill it). There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, we do not anticipate this movement to be consequential to the animal over the long-term (Southall et al 2007). Based on the estimated abundance of blue, fin, sei, and sperm whales in the action area, and the number of instances of behavioral disruption expected, individuals of these species could be exposed, and respond, to Navy sonar more than once per year (Table 93). Therefore, we do anticipate repeat exposures, but animals would be exposed periodically and based on the available literature that indicates infrequent exposures are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015b; NAS 2017; New et al. 2014; Southall et al. 2007d; Villegas-Amtmann et al. 2015), we do not expect this level of exposure to impact the fitness of exposed animals.

Table 93. Estimated number of significant behavioral disruptions from Navy sonar per species in the action area.

Species	Estimated Abundance in the Action Area	Annual Behavioral Disruptions from Active Sonar	Disruptions per Animal
Blue whale	440	46	0.10
Fin whale	1,618	3,617	2.24
Sei whale	357	767	2.15
Sperm whale	3,051	26,482	8.68
North Atlantic right whale	450	451	1.00
Gulf of Mexico Bryde's whale	33	51	1.55

Note that NMFS recognizes the calculation of the number of disruptions per animal is a rough approximation of what will occur during Navy training and testing activities in the action area. Some individuals from each species could experience a few more or less disruptions annually than what is presented in Table 93. However, due to the limitations on acoustic exposure modeling capabilities, we are unable to identify which individual from each population will be exposed to and affected by a particular training or testing event in the action area. For this reason, we are not able to predict exactly how many times each animal in the action area will be exposed to and affected by Navy sonar annually. The estimates presented in Table 93 should not be viewed as exact. Instead, these estimates were presented to indicate the relative magnitude of likely exposures on an annual basis.

Further, we anticipate that any instances of TTS will be of minimum severity and short duration. This conclusion is based on literature indicating that even following relatively prolonged periods of sound exposure resulting in TTS, recovery occurs quickly (Finneran 2015). Additionally, we do not anticipate these species will experience long duration or repeat exposures within a short period of time due to the species' wide ranging life history and the fact that long duration (i.e., more than one day) Navy activities[26] also occur over large geographic areas (i.e., both the whales and the activity are moving within the action area, most likely not in the same direction). This decreases the likelihood that animals and Navy activities will co-occur for extended periods of time or repetitively over the duration of an activity. For these reasons, we do not anticipate that instances of behavioral response or TTS from Navy activities will result in fitness consequences to individual blue, fin, sei, or sperm whales.

Unlike TTS, PTS is permanent meaning the effects of PTS last well beyond the duration of the proposed action and outside of the action area as animals migrate. As such, PTS has the potential to affect aspects of an animal's life functions that do not overlap in time and space with the proposed action. While hearing loss in whales resulting from temporary exposure to PTS-causing sound levels is not expected to deafen the animals, we expect it would have some effect on the hearing ability of the whales in the frequencies of the sound that caused the damage. For the purposes of this assessment, we assume that the frequencies affected overlap with those utilized by animals for acoustic cues. Therefore, PTS from explosives may interfere with the whale's ability to hear sounds produced by ships, construction activities, seismic surveys, or communication signals of conspecifics. The ability to detect anthropogenic sounds may be important to provide information on the location and direction of human activities, and may provide a warning regarding nearby activities that may be hazardous. The ability to detect conspecifics is important for mating and mother-calf communication as discussed above with TTS. Given this, permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness.

Our exposure and response analyses indicates that two fin whales would experience PTS annually, but this PTS is expected to be minor due to the conservative methods used to calculate impacts and the Navy's proposed mitigation. With this minor degree of PTS, affected fin whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury.

For North Atlantic right whales and Gulf of Mexico Bryde's whales, there is information to suggest that individuals may be in a compromised state at the time of exposure and therefore, could be less resilient to disruptions caused by Navy sonar and other transducers. Below we discuss the risk associated with the Navy's proposed use of sonar and other transducers separately for North Atlantic right whales and Gulf of Mexico Bryde's whales.

North Atlantic Right Whale

North Atlantic right whales are expected to experience temporary threshold shift, behavioral response, and stress throughout the Atlantic coast from sonar and other transducers. Based on the

[26] With the exception of pile driving which was discussed in section 9.1.1.1.5.

Navy's modeling, a total of 552 instances of harassment are reasonably certain to occur from Navy sonar annually. Our risk analysis considers the proposed impacts and where they occur, but also the expected condition of the affected animals at the time an exposure. In general, there is evidence that North Atlantic right whales are experiencing a population-wide decline in health (Pace et al. 2017b; Rolland et al. 2016). Therefore, some individual North Atlantic right whales exposed to Navy sonar could be in a compromised state.

The Navy proposes to implement a number of procedural mitigation measures (i.e., lookouts and shutdowns when animals are observed in mitigation zones) and geographic restrictions that are expected to reduce the potential for these impacts to result in fitness consequences to individual animals or the North Atlantic right whale population. Within each of these areas, the Navy proposes to put restrictions on the use of active sonar and will not conduct Major Training Exercises. The Southeast North Atlantic Right Whale Mitigation Area occurs off the coast of Florida and Georgia and encompasses much, but not all, of the calving critical habitat designated for this species. The Northeast North Atlantic Right Whale Mitigation Area is in the Gulf of Maine and encompasses all of the area in the northeast that has been designated foraging critical habitat for the species. The Navy also proposed a Gulf of Maine Planning Awareness Area in the northeast that encompasses all of the foraging critical habitat for the species. Within this area, the Navy will not conduct Major Training Exercises.

Impacts to North Atlantic right whales are expected to occur both within areas designated as critical habitat for the species (i.e., on the calving grounds in the southeast) and outside of these areas. While there is uncertainty, where the activities occur can be indicative of what activity the animal is engaged in at the time (e.g., calving or foraging). Our analysis below separately discusses impacts expected in each area of designated critical habitat (i.e., southeast and northeast) and in areas outside of critical habitat. Based on Navy modeling, no instances of hearing impairment, significant behavioral disruption, or other adverse effects are anticipated in foraging critical habitat for North Atlantic right whales in the northeast.

Exposures in or close to Southeast Designated Critical Habitat

Off the coast of Florida and Georgia, in or in close proximity to calving critical habitat (i.e., in the Jacksonville Range Complex), a total of 197 instances of behavioral disturbance and/or TTS are estimated to occur annually from sonar (Table 91). Six instances of TTS are expected to occur annually from explosives in or in close proximity to calving critical habitat. With the exception of the Composite Training Unit Exercise (Table 12), all activities using sonar that are expected to result in TTS and behavioral harassment of North Atlantic right whale in this area are either short-term (e.g., 0.5 to 4 hours during submarine navigation and signature analysis testing) or involve a limited number of sonar platforms (since there are a limited number of sonar platforms and both the sonar platforms and animals are moving, there is a low likelihood of co-occurrence for more than a short period of time). These factors limit the potential for these instances of TTS and behavioral harassment to result in long duration exposures and, consistent with literature described previously on the response of marine mammals to sonar, we anticipate that exposed animals will be able to return to normal behavior patterns shortly after the exposure is over (minutes to hours; e.g., Goldbogen et al. 2013a; Silve et al. 2015). Similarly, we expect instances of TTS resulting from such acoustic stressors to be of limited severity and last for a short period of time (Finneran 2015). As noted in Southall et al. (2007a), disturbance is more likely to be significant if it lasts for long durations (e.g., more than 24 hours). As we do not anticipate long duration exposures, the likelihood of these instances of harassment resulting in significant impacts to the animals is low.

For longer duration activities (e.g., MTEs), particularly those utilizing multiple sonar platforms, the chance of a longer term exposure, and associated response, is increased, but as described below, we do not expect long-term exposures to occur from these activities. Depending on animal movement and where these longer duration activities actually occur within the operating areas, such exercises have the potential to result in sustained and/or repeated exposure of North Atlantic right whales. However, as noted previously, the Navy's geographic mitigations for MTEs and other exercises using active sonar (with the exception of navigation and ship object detection) minimize the likelihood of exposures of animals to these activities in critical habitat. MTEs will not be conducted in most of the Southeast critical habitat. Further, the Navy's modeling indicated very limited impacts to North Atlantic right whales from MTEs in the southeast (i.e., one instance of behavioral harassment in the Jacksonville Range Complex, which could occur within the critical habitat designated for the species).

Finally, these longer duration activities also occur over large geographic areas (e.g., Composite Training Unit Exercises can span from the coast of North Carolina to northern Florida, within the Virginia Capes and Jacksonville Range Complexes) and since both the sonar platforms and the animals will be moving, the likelihood that animals and Navy activities will co-occur for extended periods of time over the duration of the activity is low. The likelihood of calving North Atlantic right whales being exposed for long durations or multiple times is even lower than it is for males or non-calving females because these animals are generally confined to the southeast calving grounds during that time of the year. We would not anticipate calving female right whales to travel up the coast towards and into the Cherry Point and Virginia Capes Range Complexes along with the MTE or to more offshore areas in the eastern portions of the Jacksonville Range Complex. Additionally, because MTEs and most activities using active sonar will not occur in large portions of the calving critical habitat due to the proposed Southeast North Atlantic Right Whale Mitigation Area (See Section 3.4.2.2.3), animals will have refuge in this area and will not be exposed to acoustic stressors from MTEs and most activities involving active sonar while in this area.

Southall et al. (2007a) also suggested that exposures are more likely to be significant to the animal if they recur on subsequent days. Based on the number of instances of North Atlantic right whale harassment proposed in the southeast calving area and the fact that only a subset of the total population of North Atlantic right whales are expected to occur within this area, repeat acoustic exposures and associated instances of harassment could occur. However, for the reasons described below, instances of repeat exposure are not expected to be common. Based on photo identification data from the North Atlantic Right Whale Consortium Database provided by T. Gowan (T.A. Gowan, Florida Fish and Wildlife Conservation Commission, personal communication to E. Patterson, NMFS; November 8, 2017) consisting of standardized sighting records of North Atlantic right whales from 2005 to 2013 from South Carolina to Florida, an average of 157 North Atlantic right whales spent time in waters off the coast of Florida, Georgia, and South Carolina annually. According to these data, 15 percent of the animals in the area expected to be calving females and eleven percent are expected to be calves. Using the average abundance and the annual number of takes anticipated in this area (i.e., 203 instances of TTS and behavioral harassment), we estimate an average of 1.29 instances of TTS and behavioral harassment per animal in the southeast calving area. This indicates that repeat exposures are likely to occur, but would not be common, and we would not expect individual animals to experience harassment multiple days (i.e., more than 2) in a row. As described in Table 91, the activities resulting in most of the harassment within designated critical habitat and within the Navy's mitigation area are from navigation and ship object detection exercises which each last for 0.5 hours or less as the vessel or submarine is transiting into or out of port. Based on this short duration of exposure, and the minor behavioral response expected to occur from the exposure, we do not expect these responses to affect the health of individual North Atlantic right whales even though some individual animals may experience harassment more than once annually in this area.

As stated previously, stress responses are also anticipated with each of these instances of harassment. However, the literature cited in Section 9.2.1.1.1.3 suggests these acoustically induced stress responses from periodic exposure to Navy acoustic stressors will be of short duration (similar to the duration of exposure), and not result in a chronic increase is stress that could result in physiological consequences to the animal. These stress responses are expected to be in contrast to stress responses and associated elevated stress hormone levels that have been observed in North Atlantic right whales that are chronically entangled in fishing gear (Rolland et al. 2017). This is also in contrast to stress level changes observed in North Atlantic right whales due to fluctuations in chronic ocean noise. Rolland et al. (2012) documented that stress hormones in North Atlantic right whales significantly decreased following the events of September 11, 2001 when shipping was significantly restricted. This was thought to be due to the resulting decline in ocean background noise level because of the decrease in shipping traffic. Navy activities are not anticipated to result in detectable changes in ocean background noise due to the periodic nature of training and testing activities that are conducted over large geographic areas. In summary, we do not anticipate long duration exposures to occur and we do not anticipate the low number of repeat exposures to result in significant costs to affected individuals in designated critical habitat for North Atlantic right whales in the southeast. For these reasons, we do not expect Navy activities in or near designated critical habitat for North Atlantic right whales to result in fitness consequences for individual whales.

Exposures Outside of Critical Habitat

The exposure analysis indicates many of the North Atlantic right whale impacts will also occur in areas outside of designated critical habitat for the species. For example, some of the Navy's primary training areas occur off the coast of North Carolina and Virginia. By late March, North Atlantic right whales typically leave the calving grounds of the southeast and travel up the U.S. continental shelf to the Gulf of Maine (Halpin et al. 2015; Kenney et al. 2001; Knowlton et al. 2002) and during this migration, the animals will traverse these training areas (e.g., Virginia Capes). Additionally, recent evidence suggests distributional shifts of North Atlantic right whales, with passive acoustic data indicating nearly year-round presence of this species in the mid-Atlantic (Davis et al. 2017b). As detailed in Table 82 and Table 83, instances of TTS and behavioral harassment of North Atlantic right whales from acoustic stressors in these areas are expected from a number of both short-term (e.g., object detection) and long-duration (e.g., MTEs) activities.

When in these areas, one of the primary activity North Atlantic right whales are expected to be engaged in is migration (See Section 7.2.4). However, we can also expect the animals to perform other behaviors, including opportunistic foraging and resting. If North Atlantic right whales exhibited a behavioral response to Navy sonar or explosives, the normal activity of the animals would be disrupted, and it may pose some energetic cost. However, as noted previously, responses to Navy sonar and explosives are anticipated to be short-term and instances of hearing impairment are expected to be mild and short-term. Based on best available information that indicates whales resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013a; Melcon et al. 2012), we anticipate that exposed animals will be able to return to normal behavioral patterns after the exposure ends. If an animal exhibits an avoidance response, it would experience a cost in terms of the energy associated with traveling away from the acoustic source. That said, migration is not considered a particularly costly activity (Villegas-Amtmann et al. 2015). Animals may also temporarily experience disruptions to foraging activity in these areasGoldbogen et al. (2013a) hypothesized that if the temporary behavioral responses due to acoustic exposure interrupted feeding behavior, this could have impacts on individual fitness and eventually, population health. However, for this to be true, we would have to assume that an individual whale could not compensate for this lost feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would likely still be available in the environment following the cessation of acoustic exposure (i.e., sonar could cause scattering of prey, but would not be expected to injure or kill it). There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, we do not anticipate this movement to be consequential to the animal over the long term (Southall et al. 2007a). Additionally, the North Atlantic right whale's primary feeding grounds are north of the locations where most Navy training and testing activities, in particular long-duration activities such as MTEs, are anticipated to occur.

Summary for North Atlantic Right Whales

Our risk analysis for North Atlantic right whales considered the overall number of exposures to acoustic stressors that are expected to result in behavioral harassment, TTS, and stress, the duration and scope of the proposed activities expected to result in such impacts, the expected behavioral state of the animals at the time of exposure, and the expected condition of those animals. Instances of North Atlantic right whale exposure to sonar and other transducers in designated critical habitat are expected to be short-term, with the animal returning to its previous behavioral state shortly thereafter. Some exposures to longer duration activities could occur outside of critical habitat areas, but because these activities occur over large geographic areas (e.g., Composite Training Unit Exercises can span from the coast of North Carolina to northern Florida, within the VACAPES and Jacksonville Range Complexes) the likelihood is low that animals and Navy activities will co-occur for extended periods of time or repetitively over the duration of an activity. As described previously, information is not available to conduct a quantitative analysis to determine the likely fitness consequences of these exposures and associated responses because we do not have information from wild cetaceans that links short-term behavioral responses to vital rates and animal health. Harris et al. (2017a) summarized the research efforts conducted to date that have attempted to understand the ways in which behavioral responses may result in long-term consequences to individuals and populations. Efforts have been made to try and quantify the potential consequences of such responses, and frameworks have been developed for this assessment (e.g., Population Consequences of Disturbance). However, models that have been developed to date to address this question require many input parameters and, for most species, there are insufficient data for parameterization (Harris et al. 2017a). Nearly all studies and experts agree that infrequent exposures of a single day or less are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015b; NAS 2017; New et al. 2014; Southall et al. 2007d; Villegas-Amtmann et al. 2015). Based on best available information, we expect this to be the case for North Atlantic right whales exposed to Navy acoustic stressors. We do not anticipate that instances of behavioral response, TTS, and stress from Navy acoustic stressors will result in fitness consequences to individual North Atlantic right whales.

Bryde's Whale – Gulf of Mexico Subspecies

Based on the Navy's modeling, a total of 45 instances of harassment to Gulf of Mexico subspecies Bryde's whales are reasonably certain to occur from Navy sonar annually. Similar to North Atlantic right whale, exposed individuals of this species may be in a compromised state. As described in the Section 7.2.3, the Deepwater Horizon oil spill severely impacted Bryde's whales in the Gulf of Mexico, with an estimated 17 percent of the population killed, 22 percent of females exhibiting reproductive failure, and 18 percent of the population suffering adverse health effects (DWHTrustees 2016).

The Navy proposes to implement a number of procedural mitigation measures (i.e., lookouts and shutdowns when animals are observed in mitigation zones) and geographic restrictions that are expected to reduce the potential effects of Navy activities on individual Gulf of Mexico Bryde's whales or the Gulf of Mexico Bryde's whale population (See Section 3.4.2). Most notably, the Navy proposed a Bryde's Whale Mitigation Area that is coextensive with the BIA described for Bryde's whales in the Gulf of Mexico by NMFS' 2016 status review (Figure 16). Within this area, the Navy will minimize the use of hull-mounted active sonar (i.e., no more than 200 hours per year), and will limit the use of explosives to those associated with mine warfare exercises. The Navy will also not conduct ship shock trials in this area. Within the Gulf of Mexico Planning Awareness Mitigation Area, which also includes the smaller Bryde's Whale Mitigation Area, the Navy will not conduct any MTEs (Figure 16).

Within the Gulf of Mexico, Bryde's whales may be engaged in a variety of behaviors including travel, foraging, breeding, and resting. If Bryde's whales exhibit a behavioral response to Navy sonar, any of these behaviors would be disrupted posing some energetic cost. As noted in Southall et al. (2007), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. Since no Major Training Exercises will occur in the Gulf of Mexico, the long duration activities with multiple sonar platforms that have the highest potential to result in longer or repeat exposures (depending on animal and sonar platform movement) are not expected to affect this species. Typical activities occurring in the action area consist of a single platform, testing sonar capabilities, with the activity and sonar use spread out in space and time. For this reason, Bryde's whales that are exposed to sonar and other transducers will be exposed episodically over certain months or seasons when the Navy is conducting testing activities using sonar in the eastern Gulf of Mexico. When activities are conducted, both the animal and the sonar platform would be moving, most likely in different directions because it well documented that baleen whales generally avoid anthropogenic sounds. Due to the limited number of activities conducted in the Gulf of Mexico that are expected to result in harassment of this species, the relatively short duration of these exercises (i.e., no MTEs), and that both the sonar platform and the animal would be moving, we do not anticipate long duration exposures or exposures to individual animals that recur on subsequent days.

Best available information indicates that baleen whales resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013; Melcon et al. 2012). For this reason, we anticipate that exposed Bryde's whales will be able to return normal behavioral patterns after exposure ceases. Goldbogen et al. (2013) hypothesized that if the documented temporary behavioral responses interrupted feeding behavior, this could have impacts on individual fitness and eventually, population health. However, for this to be true, we would have to assume that an individual whale could not compensate for this lost feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would likely still be available in the environment following the cessation of acoustic exposure (i.e., sonar could cause scattering of prey, but would not be expected to injure or kill it). There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, we do not anticipate this movement to be consequential to the animal over the long term (Southall et al 2007). Further, we anticipate that any instances of TTS will be of minimum severity and short duration (Finneran 2015). This conclusion is based on literature indicating that even following relatively prolonged periods of sound exposure resulting TTS, recovery occurs quickly (Finneran 2015). For the reasons described above, we do not that anticipate instances of behavioral response or TTS from Navy activities will result in fitness consequences to individual Bryde's whales.

9.2.1.2 Explosives – Marine Mammals

As described previously in Section 6.1.6, explosives include, but are not limited to, bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could be detonated in the water column or on the ocean bottom. Most detonations would occur in waters greater than 200 ft in depth, and greater than 3 NM from shore, although mine warfare, demolition, and some testing detonations would occur in shallow water close to shore.

In Section 9.2.1.1.2, we presented the total estimated number of unprocessed exposures from all acoustic and explosive stressors annually. As described previously in the introduction to Section 9.2.1, only a subset of the unprocessed exposures presented in Table 78 are expected to result in injury, hearing impairment, or significant behavioral disruptions based on the criteria and thresholds described in the technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017b). This section presents information on the estimated number of exposures of ESA-listed marine mammals to explosives that are expected to result in injury, hearing impairment, or significant behavioral disruptions, the expected magnitude of effect from those exposures, and the likely responses of the animals to those effects. The exposure estimates were produced by the Navy's NAEMO modeling. We consider these estimates to be the best available data on exposure of marine mammals to acoustic stressors from the proposed action and the estimates of take resulting from this analysis are reasonably certain to occur.

9.2.1.2.1 Potential Effects of Explosives

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

The potential effects of explosions range from death, physical injury or trauma, to an observable behavioral response, to a stress response that may not be detectable. Injury can occur to organs or tissues of an animal. Hearing loss is a noise-induced decrease in hearing sensitivity, which can either be temporary or permanent. Stress can help an animal cope with changing conditions, but too much stress can result in negative physiological effects. Behavioral responses range from brief distractions to avoidance of a sound source to prolonged flight. The sections below provide additional background on the potential effects of explosives on marine mammals. In the exposure, response, and risk analyses below (i.e., Sections 9.2.1.2.2, 9.2.1.2.3, and 9.2.1.2.4, respectively), we use this information to discuss the likely effects of Navy explosive use on ESA-listed marine mammals.

9.2.1.2.1.1 Injury

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

If an animal is exposed to an explosive blast underwater, the likelihood of injury depends on the charge size, the geometry of the exposure (distance to the charge, depth of the animal and the charge), and the size of the animal. In general, an animal would be less susceptible to injury near the water surface because the pressure wave reflected from the water surface would interfere with the direct path pressure wave, reducing positive pressure exposure. Susceptibility would increase with depth, until normal lung collapse (due to increasing hydrostatic pressure) and increasing ambient pressures again reduce susceptibility. See Appendix D (Acoustic and Explosive Concepts) in the AFTT Draft EIS/OEIS (Navy 2017c) for an overview of explosive propagation and an explanation of explosive effects on gas cavities.

The only known occurrence of mortality or injury to a marine mammal due to a Navy training or testing event involving explosives occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area had been used for underwater demolitions training for at least three decades without prior known incident. On this occasion, however, a group of approximately 100-150 long-beaked common dolphins entered the mitigation zone surrounding an area where a time-delayed firing device had been initiated on an explosive with a net explosive weight of 8.76 pounds (3.97 kilograms) placed at a depth of 48 ft (14.6 m). Approximately 1 minute after detonation, three animals were observed dead at the surface. The Navy recovered those animals and transferred them to the local stranding network for necropsy. A fourth animal was discovered stranded and dead 42 NM to the north of the detonation 3 days later. It is unknown exactly how close those four animals were to the detonation. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and St. Leger 2011).

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

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

Ward and W. 1943). Results from all of these tests suggest two explosive metrics are predictive of explosive injury: peak pressure and impulse.

Impulse as a Predictor of Explosive Injury

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

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

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

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

Peak Pressure as a Predictor of Explosive Injury

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

Older military reports documenting exposure of human divers to blast exposure generally describe peak pressure exposures around 100 psi (237 dB re 1 μPa peak) to feel like slight pressure or stinging sensation on skin, with no enduring effects ((Christian and Gaspin 1974). Around 200 psi, the shock wave felt like a blow to the head and chest. Data from the Lovelace Foundation experiments show instances of gastrointestinal tract contusions after exposures up to 1,147 psi peak pressure, while exposures of up to 588 psi peak pressure resulted in many instances of no observed gastrointestinal tract effects. The lowest exposure for which slight contusions to the gastrointestinal tract were reported was 237 dB re 1 μPa peak. As a vulnerable gas-containing organ, the gastrointestinal tract is vulnerable to both high peak pressure and high impulse, which may vary to differing extents due to blast exposure conditions (i.e., animal depth, distance from the charge). This likely explains the range of effects seen at similar peak pressure exposure levels and shows the utility of considering both peak pressure and impulse when analyzing the potential for injury due to explosives.

9.2.1.2.1.2 Hearing Loss and Auditory Injury

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

Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative. There are no direct measurements of hearing loss in marine mammals due to exposure to explosive sources. The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds such as those produced by air guns. General research findings regarding TTS and PTS in marine mammals are discussed in Section 9.2.1.1.1.2 above.

9.2.1.2.1.3 Physiological Stress

Marine mammals naturally experience stress within their environment and as part of their life histories. The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction).

There are no direct measurements of physiological stress in marine mammals due to exposure to explosive sources. General research findings regarding physiological stress in marine mammals due to exposure to sound and other stressors are discussed in detail in Section 9.2.1.1.1.3 above. Because there are many unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, it is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

9.2.1.2.1.4 Masking

Masking occurs when one sound, distinguished as the “noise,” interferes with the detection or recognition of another sound. The quantitative definition of masking is the amount in decibels an auditory detection or discrimination threshold is raised in the presence of a masker (Erbe et al., 2015). Masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking 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 marine mammals due to exposure to explosive sources. General research findings regarding masking in marine mammals due to exposure to sound and other stressors are discussed in detail in Section 9.2.1.1.1.4 above. Potential masking from explosive sounds is likely to be similar to masking studied for other impulsive sounds such as air guns.

9.2.1.2.1.5 Behavioral Reactions

Any stimuli in the environment can cause a behavioral response in marine mammals, including noise from explosions. There are no direct observations of behavioral reactions from marine mammals due to exposure to explosive sounds. 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 responses or avoidance responses. Most data have come from seismic surveys that occur over long durations (e.g., on the order of days to weeks), and typically utilize large multi-air gun arrays that fire repeatedly. Seismic air gun data (See Section 9.2.1.2.1.5) provides the best available science for assessing behavioral responses to impulsive sounds (i.e., sounds from explosives) by marine mammals, but it is likely that these responses represent a worst-case scenario compared to most Navy explosive noise sources because seismic air guns are used repetitively over a long period of time in a relatively small area whereas most Navy explosives are short-term acoustic stressors (i.e., lasting the duration of a single explosion).

General research findings regarding behavioral reactions from marine mammals due to exposure to impulsive sounds, such as those associated with explosions, are discussed in detail in Section 9.2.1.2.1.5 above.

9.2.1.2.1.6 Stranding

When a marine mammal (alive or dead) swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a "stranding" (Geraci et al. 1999; Geraci and Lounsbury 2005; Perrin and Geraci 2002). Under U.S. law, a stranding is an event in the wild where: (A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance" (16 U.S.C. section 1421h).

Explosions also have the potential to contribute to strandings (via injury or behavioral responses), but such occurrences are less common than those that have been related to certain sonar activities. During a Navy training event on March 4, 2011, at the Silver Strand Training Complex in San Diego, California, three long-beaked common dolphins were killed by an underwater detonation. Further details are provided in Section 9.2.1.1.1.6 above.

9.2.1.2.1.7 Potential for Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions, masking and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. Of critical importance in discussion on the potential consequences of such effects is the health of the individual animals disturbed, and the trajectory of the population those individuals comprise. The consequences of disturbance, particularly repeated effects, would be more significant if the affected animal were already in poor condition as such animals would be less likely to compensate for additional energy expenditures or lost foraging or reproductive opportunities. 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.

9.2.1.2.2 Exposure Analysis

Section 2.2.1 presented information on the criteria and thresholds used to estimate impacts to marine mammals from explosives. Additional information on these criteria is described in the technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017b). In this section, we first present information on calculated range to effects for various explosive sources used by the Navy. We then present estimates of injury, hearing impairment, and significant behavioral disruption calculated based on these range to effects, the number and type of explosives used, and marine mammal density estimates in the action area (See Section 2.2.1 for additional detail).

Range to Effects

The following tables provide range to effects for explosives sources to the criteria and thresholds described in Section 2.2.1, as they were used in NAEMO. The range to effects are shown for a range of explosive bins from E1 (up to 0.25 pound net explosive weight) to E17 (up to 58,000 pound net explosive weight). Ranges are determined by modeling the distance that noise from an explosion will need to propagate to reach exposure level thresholds specific to a hearing group that will cause a significant behavioral disruption, TTS, PTS, and non-auditory injury.

Table 94 shows the minimum, average, and maximum ranges due to varying propagation conditions to non-auditory injury as a function of animal mass and explosive bin (i.e., net explosive weight). Ranges to peak pressure-based injury typically exceed ranges to impulse-based injury. Therefore, the maximum range to effect is not mass-dependent. Animals within these ranges would be expected to receive minor injuries at the outer ranges, increasing to more substantial injuries, and finally mortality as an animal approaches the detonation point. Ranges to mortality, based on animal mass, are shown in Table 95.

Table 94. Ranges to non-auditory injury for all marine mammal hearing groups (Navy 2017a).

Bin	Range (m)
E1	22 (22—35)
E2	25 (25—30)
E3	46 (35—75)
E4	63 (0—130)
E5	75 (55—130)
E6	97 (65—390)
E7	232 (200—270)
E8	170 (0—490)
E9	215 (100—430)
E10	251 (110—700)
E11	604 (400—2,525)
E12	436 (130—1,025)
E16	1,844 (925—3,025)
E17	3,649 (1,000—14,025)

[1] Distances in meters (m). Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses. Modeled ranges based on peak pressure for a single explosion generally exceed the modeled ranges based on impulse (related to animal mass and depth); therefore, ranges shown are not animal mass-dependent.

Table 95. Ranges to mortality for all marine mammal hearing groups as a function of animal mass (Navy 2017a).

Bin	Representative Animal Mass (kilograms)					
	10	250	1,000	5,000	25,000	72,000
E1	4 (3—5)	1 (0—3)	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)
E2	5 (5—7)	3 (0—5)	0 (0—2)	0 (0—0)	0 (0—0)	0 (0—0)
E3	11 (9—15)	6 (3—11)	3 (2—4)	0 (0—2)	0 (0—0)	0 (0—0)
E4	20 (0—45)	11 (0—30)	5 (0—13)	3 (0—6)	1 (0—2)	0 (0—2)
E5	18 (14—50)	10 (5—35)	5 (3—11)	3 (2—6)	0 (0—3)	0 (0—2)
E6	26 (17—75)	14 (0—55)	7 (0—20)	4 (3—10)	2 (0—4)	1 (0—3)
E7	100 (75—130)	49 (25—95)	21 (17—30)	13 (11—15)	7 (6—7)	5 (4—6)
E8	69 (0—140)	36 (0—100)	16 (0—30)	12 (0—17)	6 (0—8)	5 (0—7)
E9	58 (40—200)	26 (17—55)	14 (11—18)	9 (8—11)	5 (4—5)	4 (3—5)
E10	107 (40—320)	39 (19—220)	18 (14—35)	12 (10—21)	6 (6—9)	5 (4—6)
E11	299 (230—675)	163 (90—490)	74 (55—150)	45 (35—85)	24 (21—40)	19 (15—30)
E12	194 (60—460)	82 (25—340)	22 (18—30)	15 (12—17)	8 (7—9)	6 (5—7)
E16	1,083 (925—1,525)	782 (500—1,025)	423 (350—550)	275 (230—300)	144 (130—150)	105 (90—120)
E17	1,731 (925—2,525)	1,222 (700—2,275)	857 (575—1,025)	586 (470—825)	318 (290—340)	244 (210—280)

[1] *Distances in meters (m). Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses.*

Table 96 through Table 99 show the minimum, average, and maximum ranges to onset of auditory and behavioral effects from explosives based on the thresholds described in Section 2.2. Ranges are provided for a representative source depth and cluster size for each bin. For events with multiple explosions, sound from successive explosions can be expected to accumulate and increase the range to the onset of an impact based on SEL thresholds. Modeled ranges to TTS and PTS based on peak pressure for a single explosion generally exceed the modeled ranges based on SEL even when accumulated for multiple explosions. Peak pressure-based ranges are estimated using the best available data. However, data on peak pressure at far distances from explosions are very limited.

Table 96. Sound exposure level based ranges to PTS, TTS, and behavioral response for low-frequency cetaceans (Navy 2017a)

Range to Effects for Explosives: Low Frequency Cetaceans[1]					
Bin	**Source Depth (m)**	**Cluster Size**	**PTS**	**TTS**	**Behavioral**
E1	0.1	1	54 (45—80)	259 (130—390)	137 (90—210)
		20	211 (110—320)	787 (340—1,525)	487 (210—775)
E2	0.1	1	64 (55—75)	264 (150—400)	154 (100—220)
		2	87 (70—110)	339 (190—500)	203 (120—300)
E3	18.25	1	211 (190—390)	1,182 (600—2,525)	588 (410—1,275)
		50	1,450 (675—3,275)	8,920 (1,525—24,275)	4,671 (1,025—10,775)
E4	15	1	424 (380—550)	3,308 (2,275—4,775)	1,426 (1,025—2,275)
		5	1,091 (950—1,525)	6,261 (3,775—9,525)	3,661 (2,525—5,275)
	19.8	2	375 (350—400)	1,770 (1,275—3,025)	1,003 (725—1,275)
	198	2	308 (280—380)	2,275 (1,275—3,525)	1,092 (850—2,275)
E5	0.1	25	701 (300—1,525)	4,827 (750—29,275)	1,962 (575—22,525)
E6	0.1	1	280 (150—450)	1,018 (460—7,275)	601 (300—1,525)
	30	1	824 (525—1,275)	4,431 (2,025—7,775)	2,334 (1,275—4,275)
E7	15	1	1,928 (1,775—2,275)	8,803 (6,025—14,275)	4,942 (3,525—6,525)
E8	0.1	1	486 (220—1,000)	3,059 (575—20,525)	1,087 (440—7,775)
	45.75	1	1,233 (675—3,025)	7,447 (1,275—19,025)	3,633 (1,000—9,025)
	305	1	937 (875—975)	6,540 (3,025—12,025)	3,888 (2,025—6,525)
E9	0.1	1	655 (310—1,275)	2,900 (650—31,025)	1,364 (500—8,525)
E10	0.1	1	786 (340—7,275)	7,546 (725—49,025)	3,289 (550—26,525)
E12	45.75	1	3,133 (925—8,275)	16,365 (1,775—50,275)	8,701 (1,275—23,775)
E12	0.1	1	985 (400—6,025)	7,096 (800—72,775)	2,658 (625—46,525)
E16	61	1	10,155 (2,025—21,525)	35,790 (18,025—69,775)	25,946 (14,025—58,775)
E17	61	1	17,464 (8,275—39,525)	47,402 (21,025—93,275)	34,095 (16,275—86,275)

Table 97. Peak pressure based ranges to PTS and TTS for low frequency cetaceans (Navy 2017a).

Range to Effects for Explosives: Low Frequency Cetaceans[1]			
Bin	**Source Depth (m)**	**PTS**	**TTS**
E1		127 (75—170)	226 (100—270)
E2	0.1	120 (85—150)	189 (110—270)
E3	18.25	336 (260—1,275)	674 (420—2,275)
E4	15	522 (410—875)	1,159 (775—2,025)
	19.8	431 (390—575)	892 (700—1,275)
	198	401 (360—490)	840 (650—1,775)
E5	0.1	387 (150—500)	622 (210—1,275)
E6	0.1	459 (230—625)	724 (370—1,525)
	30	871 (550—1,775)	1,519 (925—2,525)
E7	15	1,914 (1,525—2,275)	3,643 (3,025—4,525)
E8	0.1	703 (360—1,525)	1,062 (525—5,275)
	45.75	1,438 (675—3,525)	2,443 (975—7,025)
	305	1,153 (975—2,025)	3,210 (1,525—5,025)
E9	0.1	926 (480—3,775)	1,409 (600—5,025)
E10	0.1	997 (500—5,275)	1,993 (650—11,025)
E11	18.5	2,855 (950—7,525)	5,356 (1,025—15,525)
	45.75	2,642 (975—7,525)	4,485 (1,025—14,025)
E12	0.1	1,294 (575—4,775)	2,216 (750—17,275)
E16	61	5,118 (1,275—15,275)	12,416 (4,025—25,275)
E17	61	11,226 (3,525—22,775)	18,059 (8,275—37,275)

[1] Distances in meters (m). Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Table 98. Sound exposure level based ranges to PTS, TTS, and behavioral disturbance for mid-frequency cetaceans (Navy 2017a).

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]					
Bin	Source Depth (m)	Cluster Size	PTS	TTS	Behavioral
E1	0.1	1	26 (25—50)	139 (95—370)	218 (120—550)
		20	113 (80—290)	539 (210—1,025)	754 (270—1,525)
E2	0.1	1	35 (30—45)	184 (100—300)	276 (130—490)
		2	51 (40—70)	251 (120—430)	365 (160—700)
E3	18.25	1	40 (35—45)	236 (190—800)	388 (280—1,275)
		50	304 (230—1,025)	1,615 (750—3,275)	2,424 (925—5,025)
E4	15	1	74 (60—100)	522 (440—750)	813 (650—1,025)
		5	192 (140—260)	1,055 (875—1,525)	1,631 (1,275—2,525)
	19.8	2	69 (65—70)	380 (330—470)	665 (550—750)
	198	2	48 (0—55)	307 (260—380)	504 (430—700)
E5	0.1	25	391 (170—850)	1,292 (470—3,275)	1,820 (575—5,025)
E6	0.1	1	116 (90—290)	536 (310—1,025)	742 (380—1,525)
	30	1	110 (85—310)	862 (600—2,275)	1,281 (975—3,275)
E7	15	1	201 (190—220)	1,067 (1,025—1,275)	1,601 (1,275—2,025)
E8	0.1	1	204 (150—500)	802 (400—1,525)	1,064 (470—2,275)
	45.75	1	133 (120—200)	828 (525—2,025)	1,273 (775—2,775)
	305	1	58 (0—110)	656 (550—750)	1,019 (900—1,025)
E9	0.1	1	241 (200—370)	946 (450—1,525)	1,279 (500—2,275)
E10	0.1	1	339 (230—750)	1,125 (490—2,525)	1,558 (550—4,775)
E11	18.5	1	361 (230—750)	1,744 (800—3,775)	2,597 (925—5,025)
	45.75	1	289 (230—825)	1,544 (800—3,275)	2,298 (925—5,025)
E12	0.1	1	382 (270—550)	1,312 (525—2,775)	1,767 (600—4,275)

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]					
Bin	**Source Depth (m)**	**Cluster Size**	**PTS**	**TTS**	**Behavioral**
E16	61	1	885 (650—1,775)	3,056 (1,275—5,025)	3,689 (1,525—6,525)
E17	61	1	1,398 (925—2,275)	3,738 (1,525—6,775)	4,835 (1,775—9,275)

[1] Distances in meters (m). Ave. distance is shown with the minimum and maximum distances due to varying propagation in parentheses.

Table 99. Peak pressure based ranges to PTS and TTS for mid-frequency cetaceans (Navy 2017a).

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]			
Bin	**Source Depth (m)**	**PTS**	**TTS**
E1	0.1	44 (35—75)	80 (60—110)
E2	0.1	52 (45—70)	82 (70—95)
E3	18.25	101 (95—220)	188 (170—600)
E4	15	139 (120—230)	278 (230—500)
	19.8	123 (120—130)	243 (230—300)
	198	113 (0—160)	229 (180—270)
E5	0.1	142 (85—170)	252 (110—320)
E6	0.1	175 (100—220)	306 (160—390)
	30	268 (190—575)	514 (370—1,275)
E7	15	415 (330—470)	924 (650—1,025)
E8	0.1	290 (140—350)	476 (230—925)
	45.75	433 (340—1,525)	890 (575—2,275)
	305	333 (250—420)	649 (575—800)
E9	0.1	418 (260—500)	676 (380—1,025)
E10	0.1	457 (220—775)	732 (370—2,025)
E11	18.5	904 (525—2,275)	1,686 (750—4,275)
	45.75	978 (600—2,525)	1,713 (675—5,525)

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]			
Bin	Source Depth (m)	PTS	TTS
E12	0.1	608 (340—975)	940 (460—3,775)
E16	61	3,143 (1,000—7,525)	4,580 (1,025—11,025)
E17	61	4,035 (1,025—11,025)	6,005 (1,275—15,275)

[1] Distances in meters (m). Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Exposure Estimates

Table 100 lists the marine mammal estimates of PTS, TTS, and behavioral impacts for the marine mammal species considered in this opinion for Navy training and testing activities using explosives (except ship shock trials) conducted annually in the action area. Note that only the most severe impact expected (i.e., PTS>TTS>behavioral) is quantified in this table. Estimated impacts from ship shock trials are presented separately below as these activities do not occur every year.

Table 100. Estimated ESA-listed marine mammal impacts per year from explosives during training and testing activities. This table excludes estimated impacts from ship shock trials.

Species	Training/Testing	PTS	TTS	Behavioral
Blue whale	Training	0	0	0
	Testing	0	0	0
	TOTAL	0	0	0
Bryde's whale – Gulf of Mexico subspecies	Training	0	0	0
	Testing	0	1	0
	TOTAL	0	1	0
Fin whale	Training	3	32	0
	Testing	1	38	0
	TOTAL	4	70	0
North Atlantic right whale	Training	0	8	0
	Testing	0	10	0
	TOTAL	0	18	0
Sei whale	Training	0	2	0
	Testing	0	5	0
	TOTAL	0	7	0
Sperm whale	Training	0	3	2
	Testing	0	3	2
	TOTAL	0	6	4

Estimated impacts from small and large ship shock trials are presented separately as these activities do not occur annually. Small ship shock trials are proposed to occur three times every five years and large ship shock trials are proposed for once every five years. Estimated impacts from large ship shock trials are presented in Table 101 and estimated impacts from small ship shock trials are presented in Table 102.

Table 101. Estimated ESA-listed marine mammal impacts from large ship shock trials. This activity is conducted once every five years.

Species	Mortality	Injury	PTS	TTS
Blue whale	0	0	0	1
Bryde's whale – Gulf of Mexico subspecies	0	0	1	3
Fin whale	0	0	27	234
North Atlantic right whale	0	0	0	2
Sei whale	0	0	4	27
Sperm whale	0	1	3	3

Table 102. Estimated ESA-listed marine mammal impacts from a small ship shock trial. This event could occur up to three times in any given year and no more than three times over a 5-year period. Impacts for one small full ship shock trial are shown.

Species	Mortality	Injury	PTS	TTS
Blue whale	0	0	0	0
Bryde's whale – Gulf of Mexico subspecies	0	0	0	0
Fin whale	0	0	3	131
North Atlantic right whale	0	0	0	1
Sei whale	0	0	1	12
Sperm whale	0	0	1	1

9.2.1.2.3 Response Analysis

Non-Auditory Injury

As described in the technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017b), the injury threshold is based on the exposure level expected to result in onset of slight lung injury (i.e., slight lung hemorrhage). The mortality threshold is based on the exposure level expected to result in extensive lung hemorrhage. The data used to derive the threshold equations for onset of slight lung injury and onset of mortality are from Richmond et al. (1973). No test animals in the Richmond et al. (1973) study died within the first two hours of blast exposure, but longer-term survival rates were not studied. Though there is some uncertainty because longer-term survival rates were not studied by Richmond et al. (1973), it reasonable to assume that animals with slight lung hemorrhage could survive, whereas those with extensive lung injuries would not (Navy 2017a).

The NAEMO modeling indicated that one sperm whale would be injured (i.e., experience slight lung injury) due to a large ship shock trial (Table 101). This activity is conducted once every five years. No other ESA-listed marine mammals are expected to experience non-auditory injury from Navy explosives in the action area (See Table 100, Table 101, and Table 102).

Hearing Loss

The response of ESA-listed cetaceans from exposure to explosives resulting in PTS or TTS is expected to be similar to the response of ESA-listed cetaceans experiencing hearing loss due to sonar or other transducers. The exception is that because active sonar is transmitted at a specified frequency, animal's experiencing TTS or PTS from sonar will only experience threshold shifts around that particular frequency. In contrast, explosives are a broadband source, so if an animal experiences TTS or PTS from explosives, a greater frequency band will be affected. Because a greater frequency band will be affected due to explosives, there is increased chance that the hearing impairment will affect frequencies utilized by animals for acoustic cues. Table 100, Table 101, and Table 102 provides information on the number of instances of PTS and TTS anticipated for each species.

Behavioral response

The exposure analysis indicates that only a few exposures to explosives are expected to result in significant behavioral disruptions of sperm whales. No other ESA-listed marine mammals are expected to experience a significant behavioral disruption from Navy explosives in the action area (See Table 100, Table 101, and Table 102).

There are no direct observations of behavioral reactions from marine mammals due to exposure to explosive sounds. General research findings regarding potential behavioral reactions from marine mammals due to exposure to impulsive sounds, such as those associated with explosions, are discussed in detail in Section 9.2.1.2.1 above. Behavioral reactions from explosive sounds could be similar to reactions studied for other impulsive sounds such as those produced by seismic air guns (e.g., startle reactions, avoidance of the sound source), but there are important differences in how seismic surveys using air guns are conducted compared with explosive use by the Navy. Seismic surveys using air guns are typically conducted over transects and successive air gun blasts occurring over a sustained period of time. In contrast, Navy explosive use typically involves a single detonation or series of detonations conducted over a short period of time. Due to the sustained nature of seismic air gun use, behavioral responses due to seismic activity are anticipated to be more significant than could be expected from Navy explosives. The available information on the response of sperm whales to impulsive sound sources indicates animals may alert to the sound source, may alter foraging behavior, or exhibit avoidance behavior. However, these responses are expected to be temporary with behavior returning to a baseline state shortly after the activity using explosives ends.

9.2.1.2.4 Risk Analysis

In this section, we assess the likely consequences of the responses to the individuals that have been exposed to explosive stressors. In the exposure and response analysis, we established that a range of impacts including non-auditory injury, hearing loss, and behavioral response are likely to occur due to exposure to Navy explosives during training and testing events (See Table 100, Table 101, and Table 102). The majority of impacts are expected to be in the form of TTS, though some instances of PTS are also expected, particularly from ship shock trials. North Atlantic right, blue, fin, sei, Bryde's (Gulf of Mexico sub-species), and sperm whales are anticipated to experience TTS from explosive exercises and sperm whales are expected to experience behavioral responses. Fin, sei, and sperm whales are anticipated to experience PTS. Additionally, the large ship shock trial is anticipated to result in one sperm whale non-auditory injury during the five-year proposed MMPA rule, and each subsequent five-year period into the reasonably foreseeable future. As described in the exposure analysis, no other non-auditory injuries of ESA-listed marine mammals are reasonably certain to occur due to the use of explosives.

As described in the response analysis, the injury threshold is based on the exposure level expected to result in onset of slight lung injury (i.e., slight lung hemorrhage) and the mortality threshold is based on the exposure level expected to result in extensive lung hemorrhage. For the purposes of this impact assessment, we assume that the sperm whale experiencing non-auditory injury due to the large ship shock trial would be temporarily impaired due to its injury. While the animal is recovering from its injury, though there is some uncertainty, we assume the animal's ability to conduct important life functions (e.g., breeding, feeding) would be diminished, but that the animal would survive. We do not have information available to determine how long the injured sperm whale would remain impaired, but it is reasonable to assume the whale would recover within several months since the injury is only expected to be slight.

To be protective in our consideration of the proposed action's effects, we assume the sperm whale experiencing non-auditory injury by Navy explosives was a reproductively mature female and that the injury suffered reduced the ability of the affected animal to reproduce during the period of recovery. The inter-birth interval is generally 4-6 years for most sperm whales (NMFS 2015c). Because of this long period of time between births, we assume that the injured animal may miss, at most, one pregnancy. This would be a reduction in the reproductive potential of the individual sperm whale affected.

As described previously, because marine mammals depend on acoustic cues for vital biological functions (e.g., orientation, communication, finding prey, avoiding predators), fitness consequences could occur to individual animals from hearing threshold shifts that last for a long period of time (e.g., PTS), occur at a frequency utilized by the animal for acoustic cues, and/or are of a profound magnitude. It is important to note that the NAEMO modeling and classification of modeled effects from acoustic stressors, such as TTS and PTS, are performed in a manner as to conservatively overestimate the impacts of those effects. Acoustic stressors are binned and all stressors within each bin are modeled as the loudest source, necessarily overestimating impacts within each bin. Additionally, the thresholds for PTS and TTS (and therefore the PTS and TTS estimates) are for the onset of such effects, as opposed to a severe case of such effects. Further, the Navy's mitigation measures (i.e., not deploying an explosive when a marine mammal is in the mitigation zone) will minimize the likelihood that large whales will be close to the impact area at the time of detonation. This reduces the potential for more severe instances of PTS. In addition to this procedural mitigation, specific to Bryde's whales, during consultation, the Navy agreed to move the northern Gulf of Mexico ship shock trial box west, out of the Bryde's whale BIA, including a 5 NM buffer (Figure 16). This buffer with the BIA (i.e., the location where Bryde's whales are anticipated to occur) significantly limits the potential for a severe case of PTS to occur for this species.

In most cases, the temporary duration of TTS is expected to be on the shorter end of the range and last briefly. Even longer duration TTS is only expected to last hours or at most a few days (Finneran 2015). The brief amount of time marine mammals are expected to experience TTS is unlikely to significantly impair their ability to communicate, forage, or breed and is not expected to have fitness consequences for the individuals affected.

Unlike TTS, PTS is permanent meaning the effects of PTS last well beyond the duration of the proposed action and outside of the action area as animals migrate. As such, PTS has the potential to affect aspects of an animal's life functions that do not overlap in time and space with the proposed action. While hearing loss in whales resulting from temporary exposure to PTS-causing sound levels is not expected to deafen the animals, we expect it would have some effect on the hearing ability of the whales in the frequencies of the sound that caused the damage. Because explosives are a broadband source, a larger range of frequencies could be affected than with sonar. For the purposes of this assessment, we assume that the frequencies affected overlap with those utilized by animals for acoustic cues. Therefore, PTS from explosives may interfere with the whale's ability to hear sounds produced by ships, construction activities, seismic surveys, or communication signals of conspecifics. The ability to detect anthropogenic sounds may be important to provide information on the location and direction of human activities, and may provide a warning regarding nearby activities that may be hazardous. The ability to detect conspecifics is important for mating and mother-calf communication as discussed above with TTS. For odontocetes such as sperm whales, PTS also has the potential to affect an animal's ability to echolocate to find food. Given this, permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness.

Our exposure and response analyses indicate that some whales would experience PTS, but this PTS is expected to be minor due to the conservative methods used to calculate impacts and the Navy's proposed mitigation. With this minor degree of PTS, a few individual fin, sei, and sperm whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. A few sperm whales could also be less efficient at foraging, but because we anticipate only minor degrees of PTS, we expect sperm whales will still be able to forage successfully.

In our response analysis, we determined that any instances of behavioral response due to explosives would be temporary. Sperm whales may alert to the sound source, alter foraging behavior, or exhibit avoidance behavior. However, these responses are expected to be temporary with behavior returning to a baseline state shortly after the activity using explosives ends. Due to the short duration of any expected behavioral responses to explosives and the limited number of behavioral responses rising to the level of take that are reasonably certain to occur, we do not anticipate behavioral responses due to explosive use will result in fitness consequences to affected sperm whales. This is supported by several studies that indicate infrequent exposures resulting in behavioral disruptions lasting a short time are unlikely to result in long-term consequences to the exposed animals (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015b; NAS 2017; New et al. 2014; Southall et al. 2007d; Villegas-Amtmann et al. 2015).

In summary, we determined that instances of behavioral response and TTS due to explosives are not anticipated to result in fitness consequences to affected North Atlantic right, blue, fin, sei, Bryde's (Gulf of Mexico sub-species), and sperm whales. However, we anticipate that instances of fin, sei, and sperm whale PTS could result in fitness consequences to the individual and the sperm whale slight lung injury will result in fitness consequences to the affected individual.

9.2.1.3 Vessel Strike – Marine Mammals

Vessel strikes from commercial, recreational, and military vessels are known to affect large whales and have resulted in serious injury and occasional fatalities to cetaceans (Berman-Kowalewski et al. 2010; Calambokidis 2012; Douglas et al. 2008; Laggner 2009; Lammers et al. 2003). Records of collisions date back to the early 17th century, and the worldwide number of collisions appears to have increased steadily during recent decades (Laist et al. 2001; Ritter 2012).

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals often, but not always (e.g., McKenna et al. 2015), engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Amaral and Carlson 2005; Au and Green 2000; Bain et al. 2006; Bauer 1986b; Bejder et al. 1999; Bejder and Lusseau. 2008; Bejder et al. 2009; Bryant et al. 1984b; Corkeron 1995; Erbe 2002; Félix 2001; Goodwin and Cotton 2004; Lemon et al. 2006; Lusseau 2003; Lusseau 2006; Magalhaes et al. 2002; Nowacek et al. 2001; Richter et al. 2003c; Scheidat et al. 2004; Simmonds 2005; Watkins 1986a; Williams et al. 2002b; Wursig et al. 1998b). Several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994; Evans et al. 1992; Evans et al. 1994). Water disturbance may also be a factor. These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators. Avoidance behavior is expected to be even stronger when the Navy is conducting training or testing activities (e.g., when active sonar or explosives are in use).

The most vulnerable marine mammals are those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (*e.g.*, the sperm whale). In addition, some baleen whales, such as the North Atlantic right whale, seem generally unresponsive to vessel sound, making them more susceptible to vessel collisions (Nowacek et al. 2004). These species are primarily large, slow moving whales. In an effort to reduce the number and severity of strikes of the endangered North Atlantic right whale, NMFS implemented speed restrictions in 2008 (73 FR 60173; October 10, 2008). These restrictions require that vessels greater than or equal to 65 ft (19.8 m) in length travel at less than or equal to 10 knots near key port entrances and in certain areas of right whale aggregation along the U.S. eastern seaboard. Conn and Silber (2013a) estimated that these restrictions reduced total ship strike mortality risk levels by 80 to 90 percent.

Some researchers have suggested the relative risk of a vessel strike can be assessed as a function of animal density and the magnitude of vessel traffic (e.g., Fonnesbeck et al. 2008; Vanderlaan et al. 2008). Differences among vessel types also influence the probability of a vessel strike. The ability of any ship to detect a marine mammal and avoid a collision depends on a variety of factors, including environmental conditions, ship design, size, speed, and personnel, as well as the behavior of the animal. Vessel speed, size, and mass are all important factors in determining if injury or death of a marine mammal is likely due to a vessel strike. For large vessels, speed and angle of approach can influence the severity of a strike. For example, Vanderlaan and Taggart (2007) found that between vessel speeds of 8.6 and 15 knots, the probability that a vessel strike is lethal increases from 0.21 to 0.79. Large whales also do not have to be at the water's surface to be struck. Silber et al. (2010b) found when a whale is below the surface (about one to two times the vessel draft), there is likely to be a pronounced propeller suction effect. This suction effect may draw the whale into the hull of the ship, increasing the probability of propeller strikes.

There are some key differences between the operation of military and non-military vessels, which make the likelihood of a military vessel striking a whale lower than some other vessels (e.g., commercial merchant vessels). Key differences include:

- Many military ships have their bridges positioned closer to the bow, offering better visibility ahead of the ship (compared to a commercial merchant vessel).
- There are often aircraft associated with the training or testing activity (which can serve as lookouts), which can more readily detect cetaceans in the vicinity of a vessel or ahead of a vessel's present course before crew on the vessel would be able to detect them.

- Military ships are generally more maneuverable than commercial merchant vessels, and if cetaceans are spotted in the path of the ship, could be capable of changing course more quickly.
- The crew size on military vessels is generally larger than merchant ships, allowing for stationing more trained lookouts on the bridge. At all times when vessels are underway, trained lookouts and bridge navigation teams are used to detect objects on the surface of the water ahead of the ship, including cetaceans. Additional lookouts, beyond those already stationed on the bridge and on navigation teams, are positioned as lookouts during some training events.
- When submerged, submarines are generally slow moving (to avoid detection) and therefore marine mammals at depth with a submarine are likely able to avoid collision with the submarine. When a submarine is transiting on the surface, there are Lookouts serving the same function as they do on surface ships.

Additionally, the Navy implements procedural mitigation (described in Section 3.4.2.1), including the use of Lookouts and minimum approach distances to reduce the likelihood of a marine mammal vessel strike.

9.2.1.3.1 Exposure Analysis

We consider vessel strike of marine mammals comprehensively, as a result of all Navy vessel movement within the action area, as opposed to in the context of specific training or testing exercises. Training and testing activities that include vessel movements in the offshore waters of the action area would primarily be conducted within the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes, but would also be conducted within the Northeast, Key West, and Gulf of Mexico Range Complexes, as well as other offshore AFTT areas. Offshore vessel movements would be widely dispersed throughout the action area, but are more concentrated near ports, naval installations, range complexes and testing ranges. Large vessel movement primarily occurs within the U.S. Exclusive Economic Zone, with the majority of the traffic flowing between Naval Stations Norfolk and Mayport.

Over a period of 18 years from 1995 to 2012 there were a total of 19 Navy vessel strikes in the action area. Eight of the strikes resulted in a confirmed death, but in 11 of the 19 strikes, the fate of the animal was unknown. It is possible that some of the 11 reported strikes resulted in recoverable injury or were not large whales at all, but it is prudent to consider that all of the strikes could have resulted in the death of a marine mammal. The maximum number of strikes in any given year was three strikes, which occurred in 2001 and 2004. The highest average number of strikes over any five year period was two strikes per year from 2001 to 2005. The average number of strikes for the entire 18-year period is 1.055 strikes per year.

In 2007, the Navy implemented Marine Species Awareness Training designed to improve the effectiveness of visual observation for marine resources including marine mammals. In subsequent years, the Navy issued refined policy guidance on ship strikes in order to collect the most accurate and detailed data possible in response to a possible incident. It is the Navy's policy to report all vessel strikes of marine mammals that are known to have occurred. All ship strikes are reported to NMFS on an annual basis. Since 2009, there have been three documented ship strikes of cetaceans involving Navy vessels in the action area. Two occurred in the Virginia Capes Range Complex and one occurred in the Lower Chesapeake Bay. Typically, the Navy is unable to identify the species of whale that has been struck. Regarding the strikes that have occurred since 2009, one of those whales was identified as a humpback whale and the other two were in areas and/or times of year where North Atlantic right whales are not known to occur (Navy MFR; May 14, 2018). There is also a record of the Navy striking a sperm whale in the North Atlantic portion of the action area (Navy MFR; September 13, 2018).

The Navy has had similar mitigation, reporting, and monitoring requirements in place since 2009 and these are proposed to continue for Phase III training and testing activities. Therefore, the conditions affecting the potential for ship strikes are the most consistent across this time frame. As a result, data from the past eight years (i.e., 2009 to 2016) were used to calculate the probability of a Navy vessel striking a whale during proposed training and testing activities in the action area. The year 2009 was selected because this coincided with when the Navy's mitigation, monitoring, and reporting requirements became standardized across the Navy with the issuance of MMPA authorizations for sonar and explosive usage in at-sea Navy ranges; acknowledges advances in Navy marine species awareness training and overall enhanced sensitivity to marine resource issues in general; and is the first year of the codification of multiple marine species mitigation measures including specific measures to avoid large whales by 500 yards as long as it is safe for navigation. The level of vessel use and the manner in which the Navy trains and tests in the future is expected to be consistent with this time period. Additionally, there have been no large-scale changes in animal abundance, distribution, or behavior since 2009 that would be expected to affect the relative susceptibility of ESA-listed large whales to vessel strike.

Because the probability of a Navy vessel strike to whales is influenced by the amount of time at sea for Navy vessels within the action area during future training and testing activities, historical vessel use (i.e., steaming days) and reported ship strike data from 2009-2016 were used to calculate the probability of a direct strike during proposed training and testing activities in the action area over the five-year period of the proposed MMPA rule (and subsequent five year periods into the reasonably foreseeable future).

There were a total of three reported vessel strikes of large whales (i.e., mysticetes or sperm whales) by Navy vessels from 2009-2016 in the action area. During this same time period, there was a total of 39,040 steaming days by Navy vessels use within the action area. Therefore, there was an average strike rate of 0.00008 strikes per steaming day. Based on the annual average from 2009-2016, the Navy estimated that 24,400 steaming days will occur over the next five years. These values were used to determine the rate parameters to calculate a series of probabilities based on a Poisson distribution. A Poisson distribution is often used to describe random occurrences when the probability of an occurrence is small (e.g., count data such as whale strike data). In modeling strikes as a Poisson process, we assume this strike rate for the future and we use the Poisson distribution to estimate the probability of a number of strikes over a defined time period in the future:

$$P\left\langle n \middle| \mu \right\rangle = \frac{e^{-\mu} \bullet \mu^{n}}{n!}$$

P(n|μ) is the probability of observing n events in some time interval, when the expected number of events in that time interval is μ. As stated previously, the Navy estimates that 24,400 steaming days would occur over the five-year period covered under the proposed MMPA authorization. Given a strike rate of 0.00008 strikes per steaming day, the expected number of strikes (μ) over a five-year period is 1.875. The Poisson distribution can then be used to estimate the probability of n where n=0 (no strikes), 1 strike, 2 strikes, etc., over the time period. For example, the equation yields a value of $P(0) = 0.153$, indicating a 15 percent probability of not striking any whales over a five-year period. The resulting probabilities of one through five strikes over the next five years, of Navy training and testing activities are:

- 15 percent probability of striking zero whales over 5 years
- 29 percent probability of striking one whale over 5 years
- 27 percent probability of striking two whales over 5 years
- 17 percent probability of striking three whales over 5 years
- 8 percent probability of striking four whales over 5 years
- 3 percent probability of striking five whales over 5 years

Based on the resulting probabilities presented in the analysis above, we anticipate that the Navy will strike up to three large whales (inclusive of ESA-listed and non ESA-listed large whales) incidental to training and testing activities within the action area over the course of the 5 years of the proposed MMPA rule. The chances of striking more than three whales is low and not reasonably certain to occur.

In addition to the procedural mitigation described in Section 3.4.2.1 to minimize risk of vessel collision, the Navy proposes to continue implementing additional measures to reduce the likelihood of striking North Atlantic right whales. These measures, which go beyond those focused on other species, have helped the Navy avoid striking a North Atlantic right whale during training and testing activities during the past 10 plus years.[27] In particular, the Navy participates in and sponsors the Early Warning System which helps Navy vessels avoid North Atlantic right whales during training and testing activities. The Early Warning System is a comprehensive information exchange network dedicated to reducing the risk of vessel strikes to

[27] The Navy has struck three large whales in the action area since 2009. One of those whales was identified as a humpback whale and the other two were in areas and/or times of year where North Atlantic right whales are not known to occur (Navy MFR; May 14, 2018).

North Atlantic right whales off the southeast United States from all mariners (*i.e.*, Navy and non-Navy vessels). The Navy, U. S. Coast Guard, U.S. Army Corps of Engineers, and NMFS collaboratively sponsor daily aerial surveys from December 1 through March 31 (weather permitting) to observe for North Atlantic right whales from the shoreline out to approximately 30–35 NM offshore. Aerial surveyors relay sightings information to all mariners transiting within North Atlantic right whale calving habitat. In the Northeast North Atlantic Right Whale Mitigation Area (Figure 14), before all vessel transits, the Navy conducts a web query or email inquiry of NOAA's North Atlantic Right Whale Sighting Advisory System to obtain the latest North Atlantic right whale sightings information. Navy vessels use the obtained sightings information to reduce potential interactions with North Atlantic right whales during transits. In this mitigation area, vessels implement speed reductions after they observe a North Atlantic right whale; if they are within 5 NM of the location of a sighting reported to the North Atlantic Right Whale Sighting Advisory System within the past week; and when operating at night or during periods of reduced visibility. Finally, the Navy will broadcast awareness notification messages with North Atlantic right whale Dynamic Management Area information (e.g., location and dates) to applicable Navy assets operating in the vicinity of the Dynamic Management Area. The information will alert assets to the possible presence of a North Atlantic right whale to maintain safety of navigation and further reduce the potential for a vessel strike. Navy platforms will use the information to assist their visual observation of applicable mitigation zones during training and testing activities and to aid in the implementation of procedural mitigation, including but not limited to mitigation for vessel movement. Implementation of these measures is expected to significantly reduce the probability of striking this particular species in the future. Because of these additional mitigation measures, it is extremely unlikely the Navy will strike a North Atlantic right whale and thus, the potential effect of vessel strike on this species is discountable.

Most Navy-reported whale strikes are not identified to the species level, making it difficult to predict which species of large whales are most likely to be struck during future training and testing activities. In order to predict the likelihood of striking any particular species, we compiled information from the latest NMFS Stock Assessment Reports (SARs) on detected annual rates of large whale serious injury and mortality from vessel collisions[28] (Table 103). The annual rates of large whale serious injury and mortality from vessel collisions indicates the relative susceptibility of large whale species to vessel strike in the Atlantic Ocean and Gulf of Mexico. To calculate the relative likelihood of striking each species, we summed the annual rates of mortality and serious injury, then divided each species' annual rate by this number. We include non ESA-listed large whales in this calculation as some of the unidentified whales struck by the Navy in previous years could have been these species as well.

[28] North Atlantic right whales were not included in this analysis due to the additional mitigation the Navy implements to minimize the risk of striking this particular species and that the Navy has not struck this species since prior to 2009 when the Navy's current vessel movement mitigation, reporting, and monitoring requirements have been in place.

Table 103. Annual rates of mortality and serious injury from vessel collisions compiled from stock assessment reports and estimated percent chance of striking each large whale species in the action area over a five-year period.

Species	Annual rate of M/SI* from vessel collision	Percent chance of ONE strike	Percent chance of TWO strike
Fin whale – Western North Atlantic stock	1.6	22.67	5.14
Sei whale – Nova Scotia stock	0.8	11.33	1.28
Minke whale – Canadian East Coast stock	1.4	19.83	3.93
Blue whale – Western North Atlantic stock	0	0	0
Humpback whale – Gulf of Maine stock	1.8	25.50	6.50
Sperm whale – North Atlantic stock	0.2	2.83	0.08
Sperm whale – Gulf of Mexico stock	0	0	0
Bryde's whale – Northern Gulf of Mexico stock	0.2	2.83	0.08

**M/SI = Mortality/Serious Injury*

The probability analysis described above concluded that there was a 15 percent chance that zero whales would be struck by Navy vessels over the next five years, indicating an 85 percent chance that at least one whale would be struck over the next five years. To estimate the percent likelihood of striking a particular species of large whale, we multiplied the relative likelihood of striking each species by the total probability of striking a whale (i.e., 85 percent). To calculate the percent likelihood of striking a particular species of large whale twice, we squared the value estimated for the probability of striking a particular species of whale (i.e., to calculate the probability of an event occurring twice, multiply the probability of the first event by the second).

The information presented in Table 103 indicates there is at least a ten percent chance of striking a fin, sei, minke, and humpback whale during the five year period of the MMPA authorization. Of those species, only fin and sei whales are listed under the ESA in the action area. Based on the relatively high likelihood of strike for these species, it is reasonable to assume that the Navy will strike one of each of these species over the five year period of the proposed rule and each subsequent five-year period.

The information presented in Table 103 indicates there is just under a three percent chance of striking a sperm whale in the North Atlantic. While this is a relatively low probability, the Navy did strike a sperm whale in 2005 in the Virginia Capes Range Complex (L. Busch, Navy, personnel communication to E. MacMillan, NMFS; September 11, 2018). Additionally, NMFS

Permits Division proposes to authorize strike of a sperm whale from the North Atlantic stock. For these reasons, it is reasonable that the Navy is likely to strike a sperm whale in the North Atlantic during the five year period of the proposed rule. The information presented in Table 103 also indicates there is just under a three percent chance of striking a Gulf of Mexico Bryde's whale. However, the Navy conducts a relatively low level of training and testing activities in the Gulf of Mexico resulting in far fewer steaming days in areas where this species occurs compared to other portions of the action area. The Navy also has geographic mitigation measures in place to avoid conduct most activities in the Bryde's whale BIA, further reducing the likelihood of a Navy vessel strike of this species. Finally, there have been no Navy strikes of any large whale species (inclusive of Bryde's whales) in the Gulf of Mexico since 1995 and the NMFS Permits Division does not propose to authorize vessel strike of this species. For all of these reasons, it is extremely unlikely the Navy will strike a Gulf of Mexico Bryde's whale and thus, the potential effect of vessel strike on this species is discountable. The information presented in Table 103 indicates there is a zero percent chance of striking a blue whale in any portion of the action area or a sperm whale in the Gulf of Mexico. Because of these low probabilities, it is extremely unlikely the Navy will strike a blue whale or sperm whale from the Gulf of Mexico stock and thus, the potential effect of vessel strike on blue whale and sperm whales from the Gulf of Mexico is discountable. Based on the probability analysis, it is also extremely unlikely the Navy will strike any particular species more than once (i.e., < 8 percent chance for all species) over a five year period.

In summary, based on the analysis presented above, we anticipate the Navy will strike one fin whale, one sei whale, and one sperm whale over the five-year period of the proposed MMPA rule, and during each subsequent five year period. We do not anticipate the Navy will strike any ESA-listed large whale species more than once during the five-year period of the proposed MMPA rule, or during subsequent five year periods.

9.2.1.3.2 Response Analysis

Vessel collisions with large whales can result in death or serious injury of the animal. Wounds resulting from ship strike may include massive trauma, hemorrhaging, broken bones, or propeller lacerations (Knowlton and Kraus 2001). Superficial strikes may not kill or result in the death of the animal. The severity of injuries typically depends on the size and speed of the vessel (Conn and Silber 2013a; Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007). Impact forces increase with speed, as does the probability of a strike at a given distance (Gende et al. 2011; Silber et al. 2010a).

An examination of all known ship strikes from all shipping sources (civilian and military) indicates vessel speed is a principal factor in whether a vessel strike results in death or serious injury (Knowlton and Kraus 2001; Laist et al. 2001; Pace and Silber 2005; Vanderlaan and Taggart 2007). In assessing records in which vessel speed was known, Laist et al. (2001) found a direct relationship between the occurrence of a whale strike and the speed of the vessel involved in the collision. The authors concluded that most deaths occurred when a vessel was traveling in excess of 13 knots.

Jensen and Silber (2003) detailed 292 records of known or probable ship strikes (inclusive of military and non-military vessels) of all large whale species from 1975 to 2002. Of these, vessel speed at the time of collision was reported for 58 cases. Of these cases, 39 (or 67 percent) resulted in serious injury or death (19 of those resulted in serious injury as determined by blood in the water, propeller gashes or severed tailstock, and fractured skull, jaw, vertebrae, hemorrhaging, massive bruising or other injuries noted during necropsy and 20 resulted in death). Operating speeds of vessels that struck various species of large whales ranged from 2 to 51 knots. The majority (79 percent) of these strikes occurred at speeds of 13 knots or greater. The average speed that resulted in serious injury or death was 18.6 knots. Pace and Silber (2005) found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45 to 75 percent as vessel speed increased from 10 to 14 knots, and exceeded 90 percent at 17 knots. Higher speeds during collisions result in greater force of impact and also appear to increase the chance of severe injuries or death. While modeling studies have suggested that hydrodynamic forces pulling whales toward the vessel hull increase with increasing speed (Clyne et al. 1999; Knowlton et al. 1995), this is inconsistent with Silber et al. (2010a), which demonstrated that there is no such relationship (*i.e.*, hydrodynamic forces are independent of speed).

In a separate study, Vanderlaan and Taggart (2007) analyzed the probability of lethal mortality of large whales at a given speed, showing that the greatest rate of change in the probability of a lethal injury to a large whale as a function of vessel speed occurs between 8.6 and 15 knots. The chances of a lethal injury decline from approximately 80 percent at 15 knots to approximately 20 percent at 8.6 knots. At speeds below 11.8 knots, the chances of lethal injury drop below 50 percent, while the probability asymptotically increases toward 100 percent above 15 knots. The Jensen and Silber (2003) report notes that the database represents a minimum number of collisions, because the vast majority probably goes undetected or unreported. In contrast, Navy vessels are likely to detect any strike that does occur due to the number of lookouts and other personnel onboard, and they are required to report all ship strikes involving marine mammals (Navy MFR; May 14, 2018).

Our exposure analysis considered vessel strike of marine mammals comprehensively, as a result of all Navy vessel movement within the action area, as opposed to in the context of specific training or testing exercises. For this reason, we are not able to predict the speed or size of Navy vessels that are expected to result in ship strikes of large whales. Because of these unknowns, we assume that all incidences of ESA-listed large whale vessel strike associated with Navy training and testing activities in the action area will result in mortality to the affected animal.

9.2.1.3.3 Risk Analysis

In our exposure analysis, we concluded that the Navy is likely to strike one fin whale, one sei whale, and one sperm whale over the five-year period of the proposed MMPA rule, and during each subsequent five year period. We do not anticipate the Navy will strike any ESA-listed large whale species more than once during the five-year period of the proposed MMPA rule. In our response analysis, we determined that all incidences of ESA-listed large whale vessel strike associated with Navy training and testing activities in the action area will result in mortality to the affected animal. Instances of mortality will remove that animal from the population.

9.2.2 Sea Turtles

This section discusses the effects of acoustic, explosives, and vessel strike stressors on ESA-listed sea turtles. Each section will provide an overview of the stressor, followed by the potential effect on sea turtles and anticipated exposure and risk of ESA-listed sea turtles from this stressor during Navy activities.

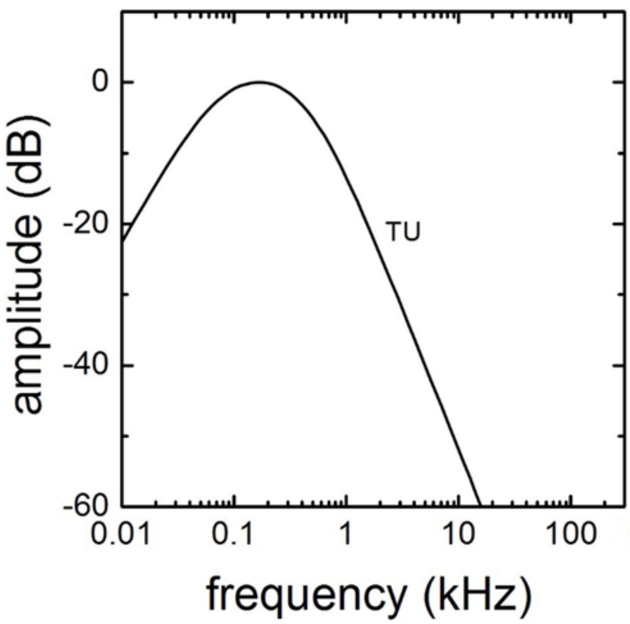
9.2.2.1 Sonars and Other Transducers – Sea Turtles

Under the Navy's proposed action, training and testing activities using sonar and other transducers could occur throughout the action area, although would mostly be concentrated in Navy complexes and testing ranges, or around identified inshore locations. Within the action area, the use of sonars is expected to be highest with anti-submarine warfare in the Jacksonville and Virginia Capes Range Complexes. The number of major training exercises and civilian port defense activities would fluctuate annually. Some anti-submarine warfare tracking exercises and ship unit level training activities would also be conducted using simulators in conjunction with other training exercises (See proposed action Section 6.1.3 for more specifics on sonar type and hours of use).

9.2.2.1.1 Potential Effect of Sonars and other Transducers for Sea Turtles

For sea turtles, the Navy analyzed potential effects from sonar and transducers in a similar manner as was applied for marine mammals, utilizing the Navy Acoustic Effects Model. For sea turtles, the animat dosimeters represent virtual distributions of sea turtles in the action area around the modeled naval activity, and each records its individual sound "dose." The distribution of animats over the action area is based upon the density values in the Navy Marine Species Density Database (Navy 2017e) and distributes animats in the water column proportional to the known time that species spend at varying depths (Navy 2017a). The model accounts for several parameters which may affect the sound level an animal is expected to receive from a sound source such as boundary interactions and environmental variability of sound propagation in both distance and depth. The Navy model then runs multiple statistical analyses based on these and other factors to estimate potential effects on animals. The number of animats that exceed the thresholds for effects (e.g. TTS, PTS, injury, behavior, etc.) for the sound sources is then calculated in order to quantify the potential number of sea turtles that could be affected. In instances where there are unknowns, NMFS and the Navy conservatively base potential effects on the worst-case scenario, which likely overestimates effects, but errs on the side of caution for sea turtles.

The Navy compiled all sea turtle audiograms available in the literature in an effort to create a composite audiogram for sea turtles as a hearing group in order to develop some of the hearing thresholds of received sound sources. Since these data were insufficient to successfully model a composite audiogram via a fitted curve as was done for marine mammals, median audiogram values were used in forming the hearing group's composite audiogram. Based on this composite audiogram and data on the onset of TTS in fishes, an auditory weighting function was created to estimate the susceptibility of sea turtles to hearing loss or damage. This auditory weighting function for sea turtles is shown below in Figure 55, and is described in detail in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis* (Phase III) (Navy 2017b). The frequencies around the top portion of the function, where the amplitude is closest to zero, are emphasized, while the frequencies below and above this range (where amplitude declines) are de-emphasized, when summing acoustic energy received by a sea turtle (Navy 2017b).



Notes: dB = decibels, kHz = kilohertz, TU = sea turtle species group

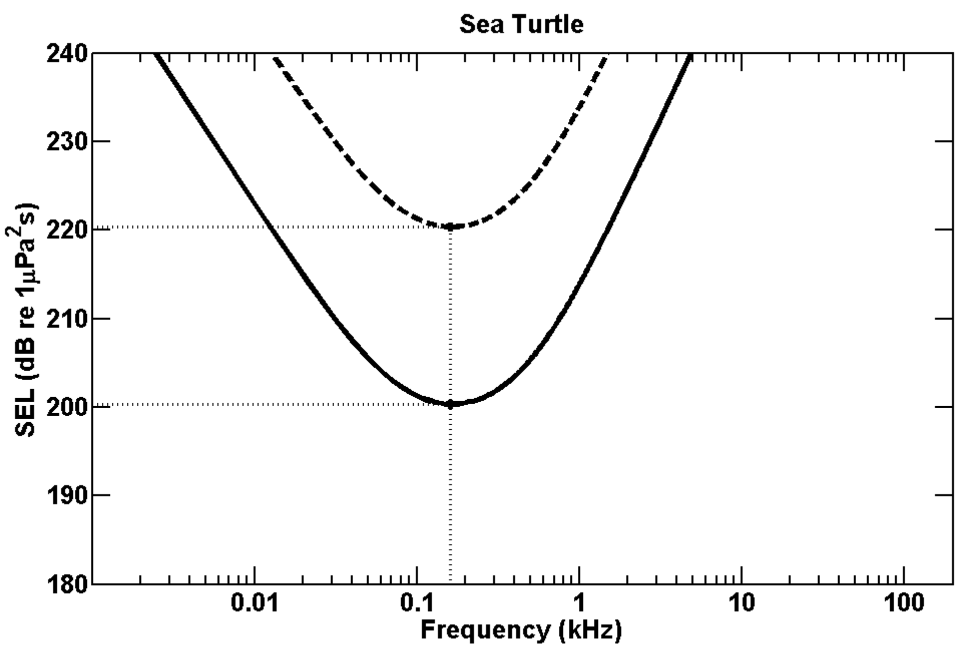
Figure 55. Auditory weighting function for sea turtles (Navy 2017a).

Sea turtle hearing capabilities and vulnerability to specific stressors was discussed previously in Sections 2.2.1 and 0 of this document. In general, sea turtles appear to be capable of detecting low-frequency sonar (less than 1000 Hz), whereas frequencies for the peak sound pressure level for mid-frequency sonar (2000 to 8000 Hz) appear out the range of sea turtle hearing sensitivity (Dow Piniak et al. 2012b). However, it may be possible for sea turtles detect high sound pressure levels of mid-frequency sonar, at increased sound pressure but no studies have been conducted to date which expose sea turtles to these levels.

Hearing Impairment - Sea Turtles

To date, no studies have been conducted specifically related to sea turtle hearing loss. The Navy evaluated sea turtle susceptibility to hearing loss (from sonar exposure) based upon what is known about sea turtle hearing abilities in combination with non-impulsive auditory effect data from other species such as marine mammals and fishes. This approach allows for the development of sea turtle exposure functions, shown below in Figure 56. These mathematical functions relate the sound exposure levels for onset of PTS or TTS to the frequency of the sonar sound. A full description of how the Navy derived these functions is provided in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis* (Phase III) (Navy 2017b).

At this time, our exposure analysis for sea turtles considers the Navy model the best available data since the Navy relies on all available information on sea turtle hearing and employ the same statistical methodology to derive thresholds as in NMFS' recently issued technical guidance for auditory injury of marine mammals (NOAA 2018). Based upon this approach, sea turtle onset of TTS would be expected to occur if received sound levels exceed 200 dB, SEL_{cum} (re: 1 μPa^2-s) and PTS would occur for sounds that exceed 220 dB SEL_{cum} (re: 1 μPa^2-s) at an exposure frequency of less than 200 Hz.



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

Figure 56. TTS and PTS exposure functions for sonar and other transducers (Navy 2017a).

Physiological stress

Stress caused by acoustic exposure has not been studied for sea turtles. As described for marine mammals, a stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. If the magnitude and duration of the stress response is too great or too long, it can have negative consequences to the animal such as low reproductive rates, decreased immune function, diminished foraging capacity, etc. Physiological stress is typically analyzed by measuring stress hormones (such as cortisol), other biochemical markers, and vital signs. To our knowledge, there is no direct evidence indicating that sea turtles will experience a stress response if exposed to acoustics stressors such as sounds from sonar. However, physiological stress has been measured for sea turtles during nesting, capture and handling (Flower et al. 2015; Gregory and Schmid 2001; Jessop et al. 2003; Lance et al. 2004), and when caught in entanglement nets and trawls (Hoopes et al. 2000; Snoddy et al. 2009). Therefore, based on their response to these other anthropogenic stressors, and including what is known about cetacean stress responses, we assume that some sea turtles will exhibit a stress response if exposed to a detectable sound stressor.

Marine animals often respond to anthropogenic stressors in a manner that resembles a predator response (Beale and Monaghan 2004b; Frid 2003; Frid and Dill 2002; Gill et al. 2001; Harrington and Veitch 1992; Lima 1998; Romero 2004). As predators generally induce a stress response in their prey (Dwyer 2004; Lopez and Martin 2001; Mateo 2007), we assume that sea turtles may experience a stress response if exposed acoustic stressors, especially loud sounds. We expect breeding adult females may experience a lower stress response, as studies on loggerhead, hawksbill, and green turtles have demonstrated that females appear to have a physiological mechanism to reduce or eliminate hormonal response to stress (predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop 2001; Jessop et al. 2000; Jessop et al. 2004). However, anthropogenic sound producing activities may have the potential to provide additional stressors beyond those that naturally occur.

Due to the limited information about acoustically induced stress responses in sea turtles, we assume physiological stress responses would occur concurrently with any other response such as hearing impairment or behavioral disruptions. However, we expect such responses to be brief, with animals returning to a baseline state within hours to days. As with cetaceans, such a short, low level stress response may in fact be adaptive and beneficial as it may result in sea turtles exhibiting avoidance behavior, thereby minimizing their exposure duration and risk from more deleterious, high sound levels.

Masking

Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Clark et al. 2009b; Erbe et al. 2016). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options.

Compared to other marine animals, such as marine mammals which are highly adapted to use sound in the marine environment, sea turtle hearing is limited to lower frequencies and is less sensitive. Because sea turtles likely use their hearing to detect broadband low-frequency sounds in their environment, the potential for masking would be limited to certain sound exposures. Only continuous anthropogenic sounds that have a significant low-frequency component, are not of brief duration, and are of sufficient received level could create a meaningful masking situation (e.g., long-duration vibratory pile extraction or vessel noise affecting natural background and ambient sounds). Other intermittent, short-duration sound sources with low-frequency components (e.g., low-frequency sonar, or air guns) would have more limited potential for masking, depending on how frequently the sound occurs.

There is evidence that sea turtles may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al. 2013), magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015), and scent (Shine et al. 2004). Thus, any effect of masking on sea turtles could be mediated by their normal reliance on other environmental cues.

Behavioral Responses

To date, very little research has been done regarding sea turtle behavioral responses relative to sonar exposure. Because of this, the working group that prepared the *ANSI Guidelines* (Popper et al. 2014) provide parametric descriptors of sea turtle behavioral responses to sonar and other transducers (Navy 2017a). The working group estimate that the risk of a sea turtle responding to a low-frequency sonar (less than 1 kHz) is low regardless of proximity to the source, and that there is no risk of a sea turtle responding to a mid-frequency sonar (1 to 10 kHz). However, for this analysis, NMFS requested that the Navy estimate the number of sea turtles that could be exposed to sonar within their hearing range at received levels of 175 dB rms re: 1 μPa SPL or greater. This level is based upon work by Mccauley et al. (2000a), who experimentally examined behavioral responses of sea turtles in response to seismic air guns. The authors found that loggerhead turtles exhibited avoidance behavior at estimated sound levels of 175 to 176 dB rms (re: 1 μPa), or slightly less, in a shallow canal. Mccauley et al. (2000a) reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB rms (re: 1 μPa). At 175 dB rms (re: 1 μPa), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (Mccauley et al. 2000a). Based on these data, NMFS assumes that sea turtles would exhibit a significant behavioral response in a manner that constitutes harassment or other adverse behavioral effects, when exposed to received levels of 175 dB rms (re: 1 μPa). This is the level at which sea turtles are expected to begin to exhibit avoidance behavior based on experimental observations of sea turtles exposed to multiple firings of nearby or approaching air guns. Because data on sea turtle behavioral responses to non-impulsive sounds, such as sonars, is limited, the air gun data set is used to inform potential risk. We considered that the relative risk of a sea turtle responding to air guns would be higher than the risk of responding to sonar, so it is likely that potential sea turtle behavioral responses to sonar exposures are a sub-set of sea turtles exposed to received levels of 175 dB rms (re: 1 μPa) or greater.

9.2.2.1.2 Exposure and Response Analysis

Based upon these criteria for potential onset of hearing loss and behavioral responses for sea turtles, the Navy provided a quantitative analysis of impacts using abundance and distribution data of sea turtles in the action area (See Section 2.2). The Navy compiled data from several sources, and developed a protocol to select the "best available data sources based on species, area, time (season, and type of density model)". The resulting GIS database called the Navy *Marine Species Density Database* includes seasonal density values for sea turtle species present within the action area (Navy 2017e).

To further differentiate between sea turtle species groups densities, the Navy developed guilds, separating hardshell turtles from non-hardshell leatherbacks. This allows estimates for densities be made for sea turtle observations where specific species identifications were not possible; but whether or not the animal possessed a hardshell. Therefore, the hardshell turtle guild is comprised of green, hawksbill, loggerhead, and Kemp's ridley sea turtles; green turtles are only considered under the hardshell turtle category because this species does not have a separate density estimate. The Navy quantified impacts on the hardshell turtle guild and these were apportioned to individual hardshell turtle species based on known geographic species densities within the action area. If enough data was available for specific species groups, those calculations were made per individual species as well. The ranges to impacts were then calculated based upon the threshold criteria described above (Navy 2017a).

Distance to Effects

As described above, the frequencies of most sonar sources are outside the range of hearing range for sea turtles. This is primarily because the sea turtle hearing range is limited to a narrow range of frequencies. Only a limited number of sonars and other transducers with frequencies are within the range of turtle hearing (e.g., <2 kHz). Furthermore, current recommended thresholds for auditory impairments are relatively high compared to most sonar frequencies, therefore very few sonar sources are considered capable of resulting in PTS and TTS for sea turtles. For these reasons, the actual number of sea turtles likely to experience injuries from sonar use during the Navy's activities is low. The Navy's calculations for PTS, TTS and behavioral effects for most[29] sonar sources are provided below in Table 104. The numbers of activities planned can vary from year-to-year, but results in the tables are based upon a "maximum sonar use year" (Navy 2017a). The Navy also included potential impacts per activity that are considered the most likely to result in impacts on sea turtles within specific regions within the action area, and are also presented in the bar charts of each figure below. For sea turtles, because of the distribution and known

[29] The Navy notes that ranges (i.e., up to tens of meters) would likely be greater for those sonars and transducers with higher source levels, however those specific ranges cannot be provided in the unclassified document provided to NMFS.

occurrences in the action area, there is potential for impacts to occur anywhere the Navy uses sonar and the species overlap. However, the Navy presented results only in regions for activity categories that had a 0.5 percent or greater probability of the impacts (Figure 57 through Figure 59). A grand total of estimated impacts for each species are also included, regardless of region or activity category (Navy 2017a).

Non-injurious behavioral responses to most sonar sources are not expected. However, based upon the Mccauley et al. (2000a) study, NMFS requested that the Navy provide exposures of sea turtles to received levels equal to or greater than 175 dBrms re 1 μPa. As described above, because this threshold is based upon exposure to air guns, the ranges to this threshold are considered conservative and likely over-estimate the ranges to potential behavioral responses to sonar and other transducers.

Take Estimates – Sea Turtles

Based upon the described Navy's quantitative analysis using the number of hours of sonar and other transducers for a maximum year of training activities, over-layed with turtle species densities, the Navy predicts no sea turtles of any species are likely to be exposed to the high received levels of sound from sonars or other transducers that lead to hearing impairment such as TTS or PTS during training activities. For testing activities, the Navy predicts only one Kemp's ridley and one leatherback sea turtle would experience TTS each year, and six loggerhead could experience TTS each year (Table 104). This results in a potential for five Kemp's ridley and leatherback sea turtles experiencing TTS from sonar, and 30 loggerheads experiencing TTS over each five year period of Navy training and testing activities.

Table 104. Estimated sea turtle impacts per year from sonar testing activities (Navy 2017a).

Species	Annual	
	TTS	PTS
Family Cheloniidae (hardshell turtles)		
Green turtle	0	0
Hawksbill turtle	0	0
Kemp's ridley turtle	1	0
Loggerhead turtle	6	0
Family Dermochelyidae (scuteless turtles)		
Leatherback turtle	1	0

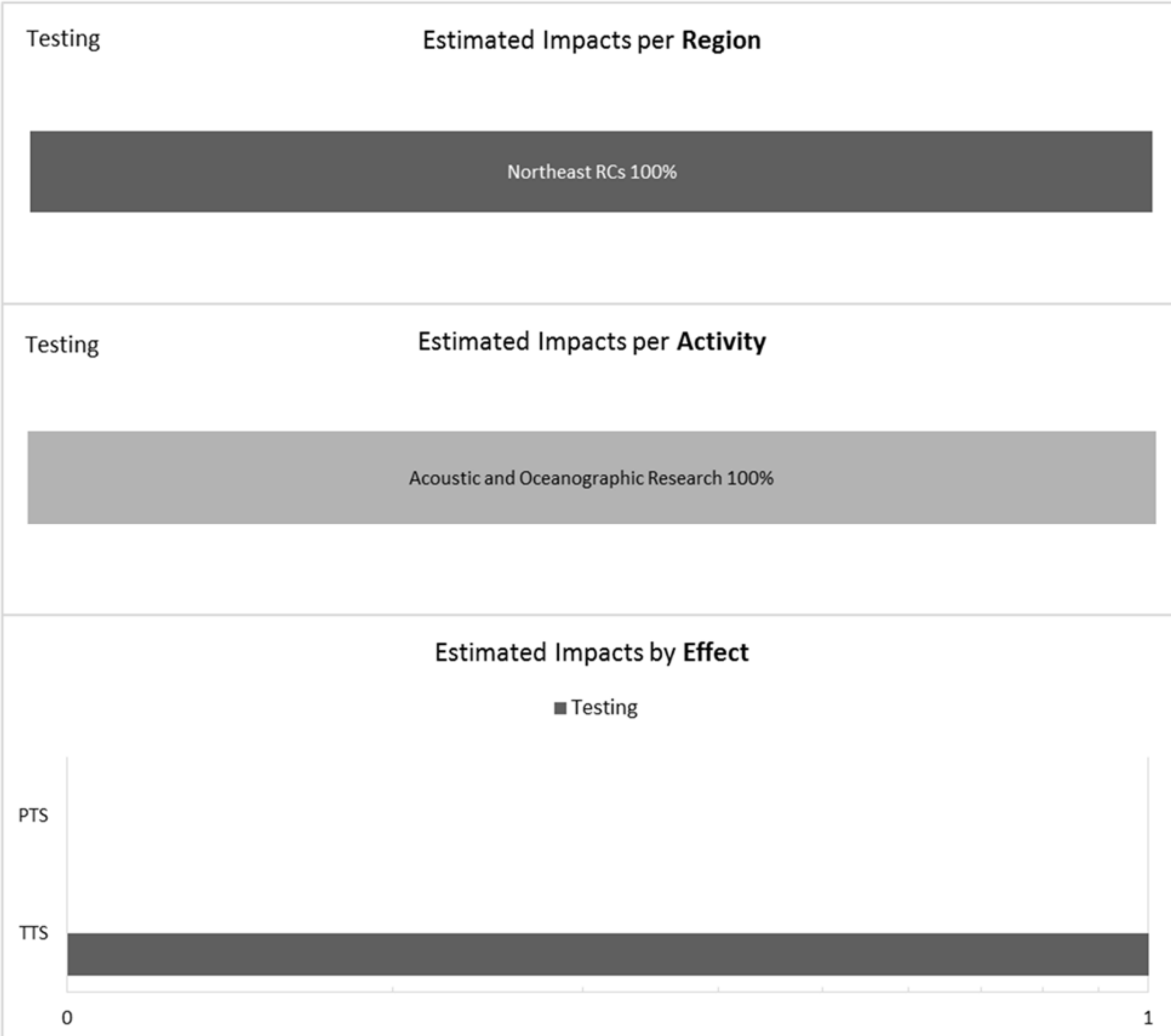
PTS: permanent threshold shift; TTS: temporary threshold shift

Although the potential for sonar exposures exists for any sea turtle species described in this biological opinion, based upon the Navy's density model and exposure risk analysis, the North Atlantic DPS of green and hawksbill sea turtles are not expected to be at risk of exposure. However, Kemp's ridley, the Northwest Atlantic DPS of loggerhead, and leatherback sea turtles are likely to be adversely affected by sonar sound exposures. These species are discussed below.

Kemp's Ridley Sea Turtle

Kemp's ridley sea turtles may be exposed to sonar and other transducers associated with Navy training and testing activities within the action area throughout the year. No Kemp's ridley sea turtles are expected to experience PTS. The Navy model predicted one Kemp's ridley sea turtle could experience TTS each year during testing activities (Figure 57). The single TTS each year would most likely occur for turtles located in nearshore areas within the action area. Four Kemp's ridley turtles are predicted to be exposed to received levels from sonar and other transducers at or exceeding 175 dBrms re 1 μPa during testing activities.

These impacts would most likely occur to hatchlings and pre-recruitment juvenile Kemp's ridley turtles within the Northeast Range Complexes (Navy 2017a). Transiting juveniles and adults may also be offshore during migration, but the Navy's model estimates the probability of sea turtles experiencing injury or behavioral effects in these areas to be extremely unlikely. Within these areas, the population of Kemp's ridley sea turtle population is estimated to be comprised of approximately one quarter-million adults and sub-adults Gallaway et al. (2013). Because of the patchy distribution of sea turtles and the transient nature of most Navy sonar activities it is unlikely that a Kemp's ridley sea turtle would be exposed more than once in a given year. Therefore, any sea turtle that experiences TTS would be expected to fully recover and not sustain long-lasting hearing impairment. The four sea turtles that may be harassed annually are also expected to resume normal behaviors once the sonar exposure has ceased. For these reasons, the five TTS exposures and 20 adverse behavioral harassment sonar exposures over the course each five year period is not expected to result in long-term or population level consequences for the Kemp's ridley sea turtle population. Given that stress responses are expected to be minor and short-term, we do not anticipate that they would impact the fitness of any individual sea turtle.



Note: Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. 100% throughout range. ASW: Anti-Submarine Warfare; RC: Range Complex. No impacts during training are estimated for this species (Navy 2017a).

Figure 57. Kemp's ridley turtle impacts estimated per year from sonar and other transducers used during testing (Navy 2017a).

Leatherback Sea Turtle

Similar to Kemp's ridley sea turtles, leatherback sea turtles may be exposed to sonar and other transducers associated with Navy training and testing activities throughout a given year. The Navy's modeling estimates one leatherback sea turtle could experience TTS each year from Navy testing in the action area (Figure 58). Two leatherback turtles (10 over five years) annually are predicted to be exposed to received levels from sonar and other transducers during testing activities at sound levels equal to or exceeding 175 dB rms (re 1 μPa), correlating with behavioral harassment.

The life stages that are more likely to experience these effects are juveniles or adults located in offshore areas located within the Northeast Range Complexes, with fewer impacts likely to occur in the Jacksonville Range Complex.

Note: Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. 100% throughout range. ASW: Anti-Submarine Warfare; RC: Range Complex. No impacts during training are estimated for this species (Navy 2017a).

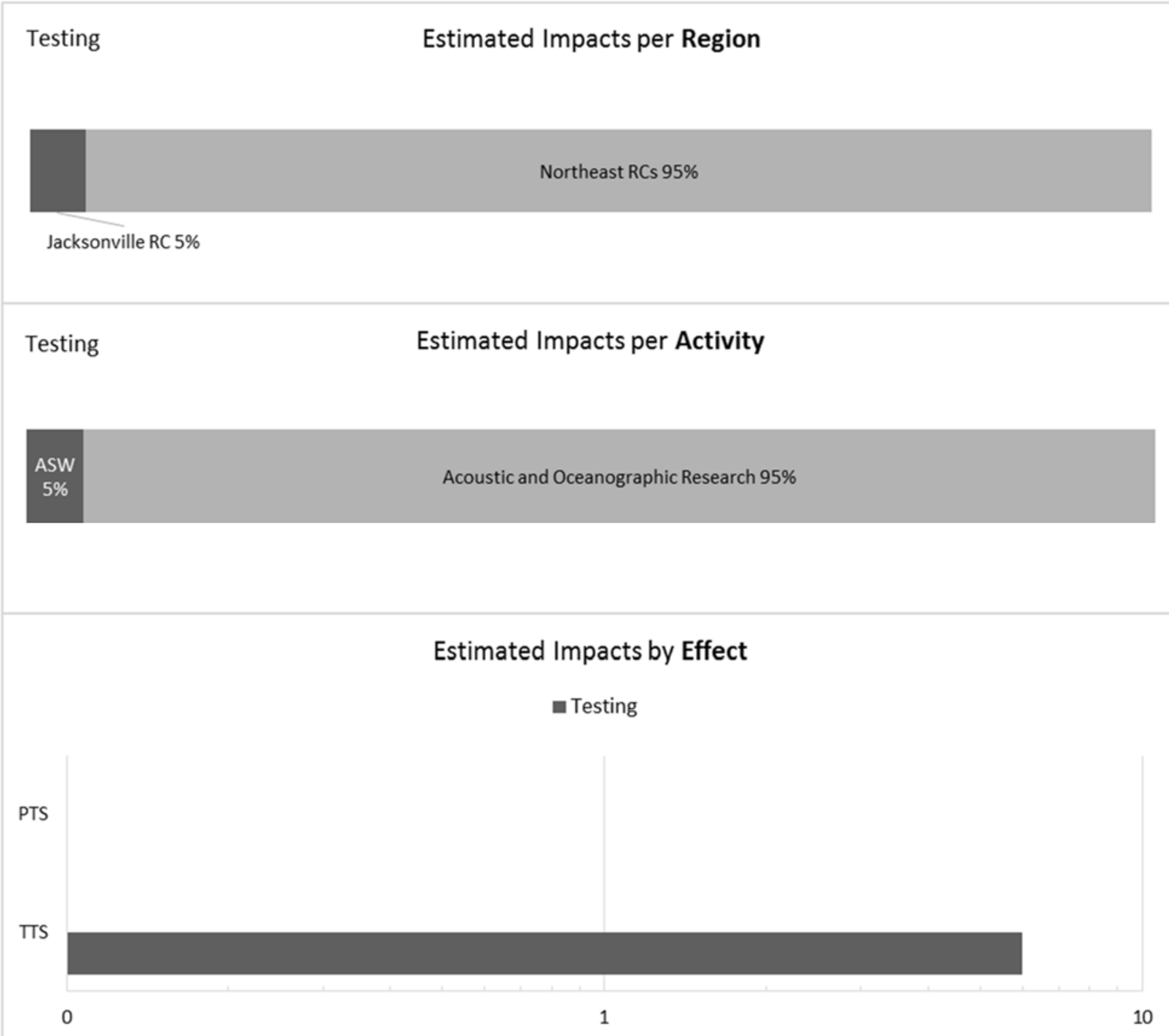
Figure 58. Leatherback turtle impacts estimated per year from sonar and other transducers used during testing (Navy 2017a).

The most recent adult population estimate for the leatherback sea turtle populations is between 34,000 to 94,000 (TEWG 2007). As with Kemp's ridley sea turtles, it is not expected for an individual animal to be exposed more than once in a given year. The single TTS is considered recoverable, with no lingering hearing impairment expected from one TTS exposure. Similarly, the two individual sea turtles that may be harassed through experiencing significant behavioral responses are not expected to suffer lingering effects, and these responses are not anticipated to interfere with carrying on normal life functions once the sea turtle no longer is exposed to sonar sound.

Loggerhead Turtle – Northwest Atlantic DPS

Loggerhead sea turtles may be exposed to sonar and other transducers associated with Navy training and testing activities each year. Six loggerhead sea turtles could experience TTS each year during testing activities, for a total of 30 sea turtles over each five year period of the Navy's proposed training and testing activities (Figure 59). Thirty-four loggerhead turtles are predicted to be exposed to received levels from sonar and other transducers at or exceeding 175 dB rms (re 1 μPa), resulting in potential significant behavioral responses for a total of 170 turtles over each five year period of Navy activities.

These effects are expected to occur for all life stages (post-hatchling, adult, or sub-adult loggerhead turtles) in open ocean areas within the Northeast Range Complexes, with fewer impacts anticipated in the Jacksonville Range Complex.



Note: Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. 100% Northwest Atlantic Ocean DPS. ASW: Anti-Submarine Warfare; RC: Range Complex. No impacts during training are estimated for this species (Navy 2017a).

Figure 59. Loggerhead turtle impacts estimated per year from sonar and other transducers used during testing (Navy 2017a).

The most recent adult female population estimate for the Northwest Atlantic DPS of loggerhead turtles is approximately 30,000 females (NMFS 2009a). As with the other species discussed above, loggerhead sea turtles who sustain TTS are not likely to be exposed to levels from sonar or transducers multiple times within a given year, therefore this temporary hearing impairment is expected to fully recover. Similarly, the 34 individuals that may experience significant behavioral responses are not expected to suffer lingering effects, and therefore the individuals experiencing these effects are not anticipated to have their ability to reproduce, forage, migrate or carry-on other normal behavioral life functions hindered from the temporary, albeit potentially more significant behavioral responses from sonar and other transducer exposures.

9.2.2.1.3 Risk Analysis

Because there are only a limited number of sonars and other transducers within the range of frequencies (and high source levels) sea turtles are thought capable of detecting (<2 kHz), the potential for permanent and temporary hearing impairment from sonar exposure is possible, but not considered a high risk that would substantially affect an individual sea turtle's ability to detect important environmental cues, or hinder important life functions. Based upon the Navy's exposure estimates, only temporary hearing impairment is expected to occur for any sea turtle exposed to this stressor. Although the proximity and context of the exposure would influence the degree of TTS a sea turtle sustains, and the length to time to recover is unknown, this hearing impairment is, by definition, considered recoverable. Therefore, any temporary loss of hearing or masking a sea turtle might experience such as the ability to detect waves, approaching vessels or predators, would eventually return to normal, and is not anticipated to cause any long-term consequences to the individual once hearing sensitivity is restored.

As discussed in Section 2.2.1.5 earlier, and in the 2014 *ANSI Guidelines*, the risk of a sea turtle responding to low-frequency sonars (less than 1 kHz) is low regardless of proximity to the source. Additionally, sea turtles are not likely capable of detecting the mid-frequency sonar (1 to 10 kHz). It is possible a turtle could respond to sounds within their limited hearing range and react, especially if they are close to the source. If this were to occur, as with other reactions to sound, sea turtles could exhibit avoidance, changes to swim speed or depth, erratic or minor behaviors.

Although sea turtle use of sound is not well understood, they generally are not thought to rely heavily on sound for many of life functions such as foraging or navigation. Similarly, the significant behavioral disruptions sea turtles may exhibit such as startle responses, temporary disruption in feeding or basking, etc. are not expected to persist. Physiological stress responses are also assumed to occur concurrent with any of these effects but would also return to normal after sonar sound exposure ceases. As described above, a short, low level stress response may be adaptive and beneficial for sea turtles in that it may result in sea turtles avoiding the stressor and minimizing their exposure. Given that stress responses are expected to be minor and short-term, we do not anticipate that they would impact the fitness of any individual sea turtle. Some of the adverse effects may be ameliorated further by the mitigation measures the Navy proposes to implement, such as powering down sonar if turtles are observed in the mitigation zone which could reduce the type (intensity and proximity to the source), severity, and duration of exposure. Therefore, we do not expect individual sea turtles that experience TTS, behavioral responses, physiological stress or temporary masking from sonar to sustain fitness consequences, and do not expect population level effects that preclude conservation and recovery of sea turtle species.

9.2.2.2 Impulsive Sound Sources (Air guns and Pile Driving) – Sea Turtles

The Navy's training and testing[30] activities involve the use of air guns and impact hammer pile driving, which are impulsive sound sources.

9.2.2.2.1 Exposure and Response Analysis – Air Guns

Under the Navy's proposed action, small air guns (12 to 60 cubic inches) would be fired pierside at the Naval Undersea Warfare Center Division, Newport Testing Range, and at offshore locations typically in the Northeast, Virginia Capes, and Gulf of Mexico Range Complexes during testing activities (Navy 2017a). Assessing whether these sounds may adversely affect sea turtles involves understanding the characteristics of the sound source produced by an impulsive sound (e.g. air gun) and how that source may be detected and responded to by sea turtles present in the vicinity of the sound. In general, sea turtles are not considered as sensitive to some anthropogenic sound sources as other species such as marine mammals, primarily due to what is known about sea turtle hearing and their use of sound, although very little is understood compared to other species. Because we know much less about how sea turtles detect and respond to sound, the impacts of impulsive sound such as air guns are difficult to assess. Nonetheless, depending on the circumstances, we assume exposure to air guns, as with other acoustic stressors, may result in auditory impairment, masking of biologically relevant sounds, behavioral responses, as well as other physiological stress responses of sea turtles.

In order to estimate exposure of ESA-listed sea turtles to sound fields generated by seismic air guns and pile driving that would be expected to result in sound-induced hearing loss (i.e., TTS or PTS), we relied on acoustic thresholds for PTS and TTS for impulsive sounds developed by Navy for Phase III activities. These thresholds were developed from the most current literature, and recommendations made by the Working Group that developed thresholds for fishes and sea turtles (Popper et al. 2014). At the time our exposure analysis was conducted, we considered these to be the best available data since they rely on all available information on sea turtle hearing and employ the same statistical methodology to derive thresholds as in NMFS' recently issued technical guidance for auditory injury of marine mammals (NOAA 2018).

Hearing Impairment

To estimate received levels from air guns and other impulsive sources such as pile driving expected to produce TTS in sea turtles, the Navy compiled all sea turtle audiograms available in the literature in an effort to create a composite audiogram for sea turtles as a hearing group (See Section 2.2.1). Because these data were insufficient to successfully model a composite audiogram via a fitted curve as was done for marine mammals, median audiogram values were used in forming the hearing group's composite audiogram. Based on this composite audiogram and data on the onset of TTS in fishes, an auditory weighting function was created to estimate the susceptibility of sea turtles to TTS. Data from fishes were used since there are currently no

[30] The Navy will not use any air guns during training activities, therefore the following analysis only includes potential impacts on sea turtles from air gun use during testing activities.

data on TTS for sea turtles and fishes are considered to have hearing more similar to sea turtles than do marine mammals (Popper et al. 2014).

Assuming a similar relationship between TTS onset and PTS onset as has been described for humans and the available data on marine mammals, an extrapolation to PTS susceptibility of sea turtles was made based on the methods proposed by Southall et al. (2007a). From on these data and analyses, dual metric thresholds were established similar to those described for marine mammals and fishes, including a 232 dB_{peak} (re: 1 μPa), and 204 dB re 1 $\mu Pa^2 \cdot s$ SEL_{cum} for onset of PTS, and 226 dB_{peak} (re: 1 μPa), and 189 dB re 1 $\mu Pa^2 \cdot s$ SEL_{cum} for onset of TTS (See Section 2.2.1 for more detail).

Behavioral response[31]

In order to estimate exposure of ESA-listed sea turtles to sound fields generated by air guns that would be expected to result in a behavioral response, we (and the Navy per our request) relied on the available scientific literature. Currently, the best available data come from studies by O'Hara and Wilcox (1990a) and McCauley et al. (2000c), who experimentally examined behavioral responses of sea turtles in response to seismic air guns. O'Hara and Wilcox (1990a) found that loggerhead turtles exhibited avoidance behavior at estimated sound levels of 175 to 176 dBrms re: 1 μPa, and 166 dBrms in a shallow canal. McCauley et al. (2000c) reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dBrms re: 1 μPa. At 175 dBrms re: 1 μPa, both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (McCauley et al. 2000c). Based on these data, we assume that sea turtles would exhibit a more significant behavioral response when exposed to received levels of 175 dBrms re: 1 μPa and higher.

In this analysis, we rely on the impulsive acoustic thresholds described above to determine sound levels at which sea turtles are expected to experience onset of auditory injury such PTS, TTS, masking, physiological stress, and exhibit behavioral responses from air gun exposure. The Navy used data for sea turtle spatial density in the action area, and the Navy's Acoustics Effects Model to calculate potential range to effects. A detailed explanation of the Navy's analysis is in the technical report "Quantitative Analysis for Estimating Acoustic and Explosive Impacts on Marine Mammals and Sea Turtles" (Navy 2017c). We used these calculations to estimate the number of instances that sea turtles could be affected by air guns used during Navy activities.

Take Estimates from Air guns

The quantitative analysis performed by the Navy used a maximum year of testing activities, sea turtles densities, and a maximum of 100 pulses of an air gun, for a single exposure duration at a single location. The small air guns that will be used do not produce sound pressures considered large enough to cause non-auditory injury. The air guns used only produce sounds capable of causing onset of PTS and TTS for sea turtles located within a short distance from the air gun.

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[31] Physiological stress and masking for sea turtles are described in the Sonar and Other Transducers section above, and not repeated here since we expect the same effect on sea turtles from acoustic stressors in general.

The Navy calculated range to effects based upon the thresholds described above and are provide in Table 105 and Table 106 for sea turtles in the action area.

Table 105. Ranges to PTS and TTS for sea turtles exposed to 100 air gun firings (Navy 2017a).

Range (m)	
Onset PTS	Onset TTS
13	100

Table 106. Ranges to behavioral response for sea turtles exposed to air gun firing(s) (Navy 2017a).

Range to Effects for Air Guns	
Source Depth (m)	Behavioral (m)[1]
3	130 (50—200)
6.1	252 (250—260)

[1] *Average distance is depicted above the minimum and maximum distances in parentheses.*

Hearing Impairment

Ranges based on the peak pressure metrics for PTS and TTS for firings of an air gun, regardless of number of firings, are at zero meters from the source. For the SEL_{cum} metrics, the onset of PTS for any sea turtle is expected if it is within 13 m from the air gun, and 100 m for TTS. Also, a sea turtle would have to remain within that zone for the entirety of the 100-pulse duration to accumulate enough sound pressure to have their hearing adversely affected. Given that the Navy will implement shut-down zones if a sea turtle or *Sargassum* rafts are observed in the mitigation zone action area, which is 150 yards (approximately 137 m), the probability of PTS and TTS occurring for sea turtles is considered to be very low as the mitigation zone extends beyond the zones for onset of both PTS and TTS. Moreover, if a sea turtle is observed within that zone, the Navy will not resume air gun use until a break of 30 minutes has occurred, or the sea turtle is seen leaving the area and would be outside the range of injurious effects. These safe boundaries surrounding areas when sea turtles or other habitat cues (i.e. jellyfish, floating vegetation, etc.) are observed during the use of air guns would help reduce the degree of exposure to the most injurious sound levels, thereby potentially reducing the severity of effects a sea turtle could experience.

Masking

Due to the brief duration of an individual air gun shot (approximately 0.1 second), and the low duty cycle of sequential shots, the potential for masking of biologically relevant cues is low during small air guns shots. Additionally, the pierside air gun use would only occur several times a year and also would only use a limited number of shots. Because of the limited duration, disruption of a sea turtles ability to detect important sounds in the surrounding environment is not likely.

Behavioral Response

For potential behavioral responses, the Navy estimates the range to effects at depth, corresponding to the threshold of 175 dB rms (re 1 μPa), would be on average 130 m away (maximum 200 m) in three meters of water depth, and 252 m away (maximum 260 m) in waters six meters deep. Any sea turtles within these zones may be able to detect the sound and could exhibit a more significant behavioral response (or experience physiological stress) such as startle, erratic or avoidance behaviors which would rise to a level of take from harassment. Based upon sea turtle density estimates in these areas, no green or hawksbill, Kemp's ridley, or leatherback turtles are expected to exhibit avoidance of or any other higher severity in behavioral responses to air guns during Navy testing.

A small number (two) Northwest Atlantic DPS loggerhead sea turtles may be exposed to received levels from air guns at or exceeding 175dB rms (re 1 μPa), and thus may exhibit a more significant behavioral response. The Navy's quantitative analysis model predicts no injuries or hearing impairment is expected to occur for loggerhead turtles based upon the number of hours of air guns use for the maximum amount of time per year of testing activities in the action area. Therefore, only significant behavioral responses are expected, and if they do occur, they could occur for any life stage (hatchling, pre-recruitment juvenile, adult, or sub-adult loggerhead) in open ocean areas within the Northeast Range Complexes; or within the Virginia Capes Range Complex.

Physiological Stress

NMFS assumes that stress responses could also accompany any behavioral responses; however stress levels are likely to return to normal once sound exposure from air guns stops. For these reasons, any significant stress responses are unlikely to occur for a sea turtle. Therefore, long-term consequences for individual sea turtles would not be expected, as behavioral responses and associated stress responses from air guns are not expected to disrupt important life functions such as foraging and reproductive success.

9.2.2.2.2 Risk Analysis – Air Guns

Although two loggerhead sea turtles are expected to be harassed from air gun exposure during the use of air guns, considering the low number of these expected exposures, the short duration of exposure, and the locations and spatial densities of sea turtles where repeat air gun activities would take place, it is unlikely the same sea turtle would be harassed more than once in a given year. Moreover, there is currently no evidence to suggest that any behavioral response would persist after a sound exposure, and given the limited duration of air gun exposures, it is assumed a sea turtle would resume normal behaviors shortly after the air gun sound ceases.

In summary, the use of air guns is likely to adversely affect up to two loggerhead sea turtles per year for a total of 10 loggerhead sea turtles during each five year period of Navy training and testing. These turtles may be harassed or experience other behavioral responses during air gun exposure, but these behavioral responses are not expected to persist once exposure to the air guns has ceased. An animal that is disturbed in this manner may temporarily be less alert to other dangers such as an approaching vessel or predator, or may temporarily stop feeding or resting. Because no hearing impairment is expected, these changes in behavior and stress responses for loggerhead sea turtles are considered temporary, and likely to return to normal within a short period of time after the turtle no longer detects the stressor. For these reasons, no long-term consequences for loggerhead sea turtles are expected, and important life functions such as growth and reproductive success are not expected to be diminished.

9.2.2.2.3 Exposure and Response Analysis – Pile Driving

Our analysis on potential impacts to sea turtles from impact[32] pile driving take into consideration the same information provided for air guns above since both are impulsive sound sources and considered to have similar effects on sea turtles. The sound criteria used to evaluate the potential effects (auditory and behavioral) on sea turtles for impulsive sound sources was described in Section 2.2.1 and above.

This section presents information on the estimated number of exposures of ESA-listed sea turtles to pile driving sound that are expected to result in incidental take, the expected magnitude of effect from those exposures, and the likely responses of sea turtles to those effects. Based on these criteria and the Navy's density model for sea turtles, the Navy calculated the range to effects for sea turtles from pile driving and removal for the Elevated Causeway, provided below in Table 107.

Table 107. Ranges to PTS and TTS for sea turtles exposed to impact pile driving for a single pile (Navy 2017a).

Type of Activity	PTS (m)	TTS (m)
Impact Pile Driving (single pile)	2	19

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

In this exposure scenario, a sea turtle may experience PTS if it is located within two meters of a pile, and TTS within 19 m of a pile. Ranges to behavioral responses, based on the distance to reach the 175 dBrms re 1 μPa isopleth, are 107 m from the pile.

Hearing Impairment

The broad range of frequencies generated from impact hammering of piles are within the range of sea turtle hearing, especially since most energy is within the lower frequencies. Based upon the calculated distances to respective thresholds for TTS and PTS, and the NAEMO spatial and

[32] Because vibratory pile extraction has a low, continuous sound source level (below 145 dBrms re 1 μPa), it is below the level where any effects to sea turtle hearing or behavioral responses are likely to occur. Therefore, potential impacts from vibratory hammer removal of piles is not expected, nor discussed further for sea turtles.

density estimates for sea turtles, the Navy estimates zero sea turtles could be exposed to levels of impact pile driving that could cause TTS or PTS.

Masking

Sea turtle hearing abilities and known use of sound to detect environmental cues is discussed above. Sea turtles are thought capable of detecting nearby broadband sounds, such as would be produced by pile driving. Thus, environmental sounds, such as the sounds of waves crashing along coastal beaches or other important cues for sea turtles, could possibly be masked for a short duration during pile driving. However, any masking would not persist beyond the period it takes to complete pile driving each day, and could be decreased if there are suitable gaps of time between piles being driven in a given day to allow sea turtles to hear biologically-relevant sounds in between driven piles. The coastal areas where pile driving will occur will also have high ambient noise levels due to breaking waves and anthropogenic sources, reducing the potential for Navy pile driving to have a significant impact on the amount of noise in the water column. If masking occurs, it would only be expected to occur for brief periods; approximately less than two hours per day for up to 30 days (20 days for construction and 10 days for pile removal) in any given year.

Behavioral response

For behavioral responses corresponding to 107 m (per the 175 dB rms level), no green, hawksbill, Kemp's ridley, or leatherback turtles are likely to be exposed to sound levels that could elicit significant behavioral responses. However, sound generated from an impact hammer can also be transmitted through the substrate, which may potentially disturb sea turtles foraging or resting near the bottom (e.g., juvenile or sub adult green, Kemp's ridley, and loggerhead turtles). However, any turtles that are exposed to sound moving through the substrate are unlikely to be affected at a level that would lead to a significant disruption of behavior due to the relatively low levels of sound anticipated to be transmitted through the substrate.

For loggerhead sea turtles, up to seven loggerhead turtles per year and 35 over each five year period of Navy training could be exposed to received impulsive sound levels exceeding 175 dBrms re 1 μPa. Some of these turtles may exhibit a significant behavioral response and therefore be considered harassed by pile driving activities.

Based on prior observations of sea turtle reactions to sound, if a behavioral reaction were to occur, the responses could include increases in swim speed, change of position in the water column, or avoidance of the sound. There is no evidence to suggest that any behavioral response would persist beyond the duration of the sound exposure. It is assumed that a stress response would also occur concurrent with the behavioral response.

9.2.2.2.4 Risk Analysis – Pile Driving

In this section, we assess the likely consequences of the responses of individuals exposed to impulsive sound stressors such as pile driving, the populations those individuals represent, and the species those populations comprise. In the exposure and response analysis, we established that a range of impacts including masking, stress, and behavioral response are likely to occur due to pile driving exposure of ESA-listed sea turtles to Navy activities.

The Navy will implement specific mitigation zones for sea turtles during pile driving events. These mitigation zones include an area of 100 yards (approximately 91 m) around a pile being driven. Pile driving will not commence if any sea turtles are seen in the 100 yard zone, and will be halted if a sea turtle is observed entering the zone. Pile driving will not resume until the conditions described in the minimization Section 3.4.2.1.3. Moreover, the mitigation zone extends beyond the range to effects for PTS and TTS. Some sea turtles could still detect the sound and may exhibit behavioral responses beyond the 100 yard zone, extending out to the distance of 107 m (per the 175 dB rms level).

In summary, because of the frequency and limited areas where pile driving will occur during any single year, it is unlikely that sea turtles will be exposed multiple times to sound from Navy pile driving. Changes in behavior and stress responses for loggerhead sea turtles are considered temporary, and likely to return to normal within a short period of time after the turtle no longer detects the stressor. Additionally, since sea turtles are not expected to be physically injured or killed from pile driving exposure or experience hearing impairment, and stress or harassment from behavioral responses will be temporary, no long-term consequences for any sea turtles, especially for the Northwest Atlantic DPS loggerhead sea turtle (which the Navy estimated to be the only species potentially exposed) population are expected. For these reasons, no long-term consequences for sea turtles are expected, and important life functions such as growth and reproductive success are not expected to be diminished from exposure to pile driving.

9.2.2.3 Explosives – Sea Turtles

As described previously in Section 6.2, explosives include, but are not limited to, bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; and mines and demolition charges could be detonated in the water column or on the ocean bottom. Most detonations would occur in waters greater than 200 ft in depth and greater than 3 NM from shore, although mine warfare, demolition, and some testing detonations would occur in shallow water close to shore.

For acoustics and explosive stressors, NMFS considered exposure estimates from the Phase III NAEMO model at several output points for sea turtles (i.e., unprocessed, model estimated, and final take estimates). These NAEMO outputs only represent estimates for larger sea turtles (i.e., those greater than 30 cm in diameter). The data used by the Navy to quantitatively assess impacts to sea turtles is primarily from NMFS' aerial surveys with supplemental data from shipboard surveys from NMFS and others. The data are largely derived from aerial surveys, corrected for sighting availability, which can only detect these larger sea turtles (Epperly et al. 1995; NMFS 2011g). For these reasons, neither age class nor size are explicitly accounted for in the sea turtle density data, although the size makes sightability and identification of age and species easier. While the density data used may not explicitly account for size of sea turtles smaller than 30 cm, the Navy's explosives analysis takes into consideration smaller sea turtle effects correlated with sea turtle mass. For example, the criteria for estimating the potential for slight lung injury and mortality are directly correlated to the mass of an animal. Therefore, juvenile weights are incorporated, and effects are considered for the population affected. At this time the Navy and NMFS are unaware are of any additional datasets which would provide size class estimates for smaller sea turtles.

During the early life histories of sea turtles, hatchlings and juveniles spend a majority of time passively floating in prevailing ocean currents and inhabiting floating *Sargassum* mats. Because of this, the major ocean currents entrain most small sea turtles in offshore gyres of the Sargasso Sea, which are far away from the locations where most of the Navy's acoustic or explosive activities would occur. Plus, given that small sea turtles would potentially be exposed to stressors while in *Sargassum* (and therefore at the sea surface), and that the Navy implements mitigation measures that includes observation for floating vegetation, effects to small sea turtles (less than 30 cm diameter) is somewhat accounted for in the Navy analysis, even if the density data does not quantitatively allow the separation of size classes.

The Navy provided NMFS with the total estimated number of unprocessed exposures for larger sea turtles from acoustic and explosive stressors (i.e., estimates were not broken out between the different acoustic stressors and explosives). This information is presented in Table 108 below. The NAEMO output estimates that larger ESA-listed sea turtles will be exposed to these stressors throughout the year. Table 108 provides the maximum annual number of unprocessed exposures for larger sea turtles of each sea turtle species considered in this biological opinion. Based on the density data used in NAEMO, estimates are also provided for larger sea turtles in the group hardshell sea turtles, which consists of green, hawksbill, loggerhead, and Kemp's ridley sea turtles that could not be identified to species during the original aerial surveys used to generate the density estimates. During the Navy's processing of NAEMO exposure estimates, hardshell turtle exposures were apportioned to individual hardshell turtle species based on known geographic species densities. The estimates in Table 108 include exposures from both annual and non-annual training and testing activities. In most years, the number of exposures would be less than listed below as non-annual activities are not conducted every year.

Table 108. Unprocessed exposure estimates of large ESA-listed sea turtles (greater than 30 centimeters) to acoustic and explosive stressors (Navy 2017a).

Species	Training/Testing	Unprocessed exposures			
		> 121 dB	> 163 dB	>181 dB	> 205 dB
Hardshell turtle (green, hawksbill, loggerhead, and Kemp's ridley)	Training	1,548,745	409,028	162,148	3,506
	Testing	2,459,312	406,525	247,430	20,392
	TOTAL	4,008,057	815,553	409,577	23,898
Kemp's Ridley turtle	Training	154,683	90,609	34,912	662
	Testing	302,535	63,258	29,344	896
	TOTAL	457,218	153,867	64,256	1,558
Loggerhead turtle	Training	3,038,554	1,300,363	516,055	12,767
	Testing	3,582,941	741,030	463,258	32,439
	TOTAL	6,621,495	2,041,394	979,313	45,206
Leatherback turtle	Training	798,523	104,113	37,571	897
	Testing	859,598	149,151	96,442	11,549
	TOTAL	1,658,121	253,264	134,013	12,447

9.2.2.3.1 Exposure and Response

We presented the total estimated number of unprocessed exposures of larger sea turtles to all acoustic and explosive stressors annually. As described previously, only a subset of the unprocessed exposures presented in Table 108 are expected to result in "take" of ESA-listed sea turtles through being killed, injured or harassed based on the criteria and thresholds described in the technical report Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles (Navy 2017b), and Section 2.3 of this biological opinion. Therefore, this section presents information on the estimated number of exposures of larger ESA-listed sea turtles to explosives that are expected to result in incidental take, the expected magnitude of effect from those exposures, and the likely responses of sea turtles to those effects. We consider the Navy's NAEMO estimates to be the best available data on exposure of larger sea turtles to acoustic and explosive stressors from the proposed action and the estimates of incidental take resulting from this analysis are reasonably certain to occur.

Table 109 lists the larger sea turtle take estimates for Navy training and testing activities using explosives (except ship shock trials) conducted annually in the AFTT action area. Note that only the most severe impact expected (i.e., injury>PTS>TTS>Behavioral) is quantified in this table for any individual sea turtle. For the behavioral takes presented in Table 109, the Navy provided estimates of the number of each species that would be exposed to sound levels exceeding 175 dB rms (re 1 μPa), and noted that a portion of these exposures may result in significant behavioral responses. Estimated impacts from ship shock trials are presented separately in Table 110 and Table 111, as these activities do not occur every year. While the Navy's estimates did not provide a quantitative estimate of sea turtles that are expected to be exposed to explosives that may result in a physiological stress response, we assume that any sea turtle that experiences injury, PTS, TTS, or exhibits a strong behavioral response may also experience a stress response, with the severity of the stress response depending on the severity of the other associated response (e.g., more severe stress response associated with PTS compared to TTS).

Table 109. Estimated large ESA-listed sea turtle (greater than 30 centimeters) impacts per year from explosives during training and testing activities. This table excludes estimated impacts from ship shock trials (Navy 2017a).

Species	Training/Testing	Injury	PTS	TTS	Behavioral
Green turtle	Training	0	1	2	2,759
	Testing	0	2	2	2,317
	TOTAL	0	3	4	5,076
Hawksbill turtle	Training	0	0	0	161
	Testing	0	0	0	156
	TOTAL	0	0	0	317
Kemp's Ridley turtle	Training	0	2	3	1,826
	Testing	0	1	4	4,830
	TOTAL	0	3	7	6,656
Loggerhead turtle	Training	4	26	57	20,628
	Testing	3	15	29	25,543
	TOTAL	7	41	86	46,171
Leatherback turtle	Training	0	2	5	1,037
	Testing	0	1	4	2,260
	TOTAL	0	3	9	3,297

Estimated impacts from small and large ship shock trials are presented separately as these activities do not occur annually. Small ship shock trials are proposed to occur three times every five years and large ship shock trials are proposed for once every five years. Estimated impacts from large ship shock trials are presented in Table 110 and estimated impacts from small ship shock trials are presented in Table 111.

Table 110. Estimated large ESA-listed sea turtle (greater than 30 centimeters) impacts from large ship shock trials. This activity is conducted once every five years (Navy 2017a).

Species	Mortality	Injury	PTS	TTS
Green turtle	0	0	1	18
Hawksbill turtle	0	0	0	2
Kemp's Ridley turtle	0	1	1	15
Loggerhead turtle	1	4	13	283
Leatherback turtle	0	2	7	215

Table 111. Estimated large ESA-listed sea turtle (greater than 30 centimeters) impacts from a small ship shock trial. This event could occur up to three times in any given year and no more than three times over a 5-year period. Impacts for one small full ship shock trial are shown.

Species	Mortality	Injury	PTS	TTS
Green turtle	0	0	1	18
Hawksbill turtle	0	0	0	2
Kemp's Ridley turtle	0	0	1	12
Loggerhead turtle	1	5	19	339
Leatherback turtle	0	1	7	169

Explosives Mortality

The NAEMO modeling indicated that one loggerhead sea turtle would be killed due to a large ship shock trial and one loggerhead sea turtle would be killed due to a small ship shock trail. Large ship shock trails are conducted once every five years and small ship shock trails could occur up to three times in any given year, but no more than three times total over a five year period. As such, up to four loggerhead sea turtles could be killed in any given year due to small ship shock trials, but on average one loggerhead sea turtle would be killed per year due to ship shock trials. For non-ship shock trial explosives, no mortalities of ESA-listed sea turtles are expected. The mortality threshold is based on the exposure level expected to result in extensive lung hemorrhage. The data used to derive the threshold equations for onset of mortality are from Richmond et al. (1973).

Non-Auditory Injury

The NAEMO modeling indicated that seven loggerhead sea turtles would be injured per year due to training and testing activities. During large ship shock trials, which would occur once every five years, four loggerhead sea turtles could be injured, and one killed. One Kemp's Ridley sea turtle, and two leatherback sea turtles, would be injured during the large ship shock trial. During small ship shock trials, which could occur up to three times within a year but not more than three times over five years, five loggerhead sea turtles and one leatherback sea turtle would be injured. Thus, within any given year, a maximum of one Kemp's Ridley sea turtle, 16 loggerhead sea turtles, and five leatherback sea turtles would be injured across all explosive activities, including ship shock trials. No green sea turtles or hawksbill sea turtles are expected to be injured or killed during training and testing activities including ship shock trials.

As described in the technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017b), the injury threshold is based on the exposure level expected to result in onset of a slight lung injury and/or contusions to the gastrointestinal tract. The data and theory used to derive these threshold are from Richmond et al. (1973) and Goertner (1982a). Though there is some uncertainty regarding whether slight lung injuries or contusions to the gastrointestinal tract may have long-term effects on survival rates due to the lack of studies, it reasonable to assume that animals with slight lung injuries or gastrointestinal tract contusions could survive, whereas those with extensive lung injuries or gastrointestinal tract contusions would not (Navy 2017b).

In addition to minor lung injuries or gastrointestinal tract contusions from the blast wave, it is possible that sea turtles may be physically injured due to fragmentation of exploding munitions. However, given that fragments would quickly decelerate in water, and that injury due to the blast wave would extend much further than any risk for from fragmentation, sea turtles that may experience injury from fragmentation are also assumed to experience injury due to the blast wave. As such, the estimates produced by NAEMO modeling for non-auditory injuries are assumed to encompass any sea turtles that may also be injured due to fragmentation.

Hearing Loss

ESA-listed sea turtles are expected to experience TTS and PTS as a result of activities involving explosives, including ship shock trials (See Table 109 to Table 111). Annually, three green, three Kemp's ridley, 41 loggerhead and three leatherback sea turtles could experience PTS during training and testing activities. During large ship shock trials, one green, one Kemp's ridley, 13 loggerhead and seven leatherback sea turtles could experience PTS. During small ship shock trials, one green, one Kemp's ridley, 19 loggerhead and seven leatherback turtles could experience PTS. Four green, seven Kemp's ridley, 86 loggerhead and nine leatherback sea turtles could experience TTS during training and testing activities annually. Eighteen green, two hawksbill, 15 Kemp's ridley, 283 loggerhead and 215 leatherback sea turtles could experience TTS during large ship shock trials. For the small ship shock trials, 18 green, two Hawksbill, 12 Kemp's ridley, 339 loggerheads and 169 leatherback sea turtles could experience TTS per year.

The response of ESA-listed sea turtles from exposure to explosives resulting in hearing loss is expected to be similar to the response of ESA-listed sea turtles experiencing hearing loss due to sonar or other transducers, with those associated with TTS expected to be only temporary, and recoverable, but those associated with PTS to be permanent. The exception is that because active sonar is transmitted at a specified frequency, sea turtles experiencing hearing loss from sonar would only experience threshold shifts around that particular frequency. In contrast, explosives are a broadband source (Hildebrand 2009b), so if an animal experiences TTS or PTS from explosives, a greater frequency band will be affected. Because of this, there is increased chance that the hearing impairment will affect frequencies utilized by sea turtles for acoustic cues such as the sound of waves, coastline noise, or the presence of a vessel or predator. That said, as noted previously sea turtles are not known to rely heavily on sound for life functions (Nelms et al. 2016; Popper et al. 2014), and instead, may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al. 2013) and magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015).

Behavioral Response

Any acoustic stimuli within sea turtle hearing ranges in the marine environment could elicit behavioral responses in sea turtles, including noise from explosions. However, there is very limited data available regarding the behavioral responses of sea turtles to most anthropogenic sound sources. As described previously, NMFS conservatively uses the limited information on sea turtle behavioral responses to air guns as a surrogate for the sound sources produced during Navy activities, including explosive exposure analysis. The Navy provided estimates of sea turtles that may experience received levels above 175 dB rms (re 1 μPa) in Table 80.

Because sea turtles exhibited avoidance behaviors to air gun exposure at levels above 175 dB rms (re 1 μPa), responses to explosive detonations could be similar, and exposures to multiple detonations over a short period may cause a sea turtle to exhibit other behavioral reactions, such as interruption of feeding or avoiding the area. However, exposure to a single blast during an event, which is the most probable scenario during Navy activities will likely result in less severe behavioral responses. Behavioral response to a single detonation would likely be a short-term startle response, and a sea turtle would presumably return to normal behaviors quickly after exposure to the blast (if it did not sustain an injury described above). As described above, the Navy did not model potential behavioral responses that would constitute take (such as harassment), nor did they provide estimates for ship shock trials due to the lack of information regarding sea turtle responses to explosives, as well as the fact that a sea turtle may not respond to some of the explosive detonations. However, NMFS assumes a subset of the number of sea turtles that could experience TTS during ship shock trails would also experience behavioral disruptions and be considered with the numbers provided in Table 112. These turtles could experience disturbance or disruption in normal behavioral patterns that would be significant enough to rise to a level of take in the form of harassment.

9.2.2.3.2 Risk Analysis

In this section, we assess the likely consequences of the responses of individuals exposed to explosive stressors, the populations those individuals represent, and the species those populations comprise. In the exposure and response analysis, we established that a range of impacts including mortality, non-auditory injury, hearing loss, and behavioral response are likely to occur due to exposure of ESA-listed sea turtles to Navy explosives during training and testing events.

Injury and hearing impairment

Based on what is known about potential sea turtle impacts from explosives studies and other Federal programs that use explosives (e.g. BOEM in the Gulf of Mexico), NMFS assumes underwater explosives can kill, injure, and impair sea turtles exposed to detonations. Lethal injuries result from massive trauma or combined trauma to internal organs as a result of close proximity to the point of detonation. Types of lethal injuries include massive lung hemorrhage, gastrointestinal tract injuries (contusions, ulcerations, and ruptures), and concussive brain damage, cranial and skeletal (shell) fractures, hemorrhage, or massive inner ear trauma (Ketten

1995). Examples of nonlethal injuries include eardrum rupture, bruising, and immobilization of severely stunned animals. Stunned animals beneath the water may drown or become vulnerable to other impacts while they are immobilized. Minor organ injuries and contusions can occur as a result of underwater explosions; however, some sea turtles would be expected to recover over time through normal healing processes. Still, delayed complications arising from nonlethal injuries may ultimately result in the death of the animal because of increased risks from secondary infection, predation, or disease; and a reduced foraging capacity.

The majority of impacts are expected to be in the form of TTS, which would occur to individuals from all ESA-listed sea turtle species considered in this opinion. In addition, instances of PTS are expected for green, Kemp's ridley, loggerhead, and leatherback sea turtles. Non-auditory injuries are expected to occur for Kemp's ridley, loggerhead, and leatherback sea turtles, and mortality is expected to occur only for loggerhead turtles. Further, all sea turtles exposed to explosives at levels expected to produce a strong behavioral response are also expected to experience a physiological stress response, with a greater stress response expected to be associated with more severe effects such as non-auditory injury and PTS. The long-term effect of mortality on individual sea turtles is clear in that it results in the immediate loss of the killed sea turtles from the population, as well as their reproductive potential. The long-term effects of physiological stress responses, TTS, PTS, and non-auditory injury and significant behavioral responses are less apparent. The risks associated with each of these is discussed below.

As described in the response analysis, the injury threshold is based on the exposure level expected to result in a slight lung injury (i.e., slight lung hemorrhage) or gastrointestinal tract contusion, wherein the mortality threshold is based on the exposure level expected to result in severe lung hemorrhage, which are not recoverable injuries. For the purposes of this impact assessment, we assume that the ESA-listed sea turtles experiencing non-auditory injuries would be temporarily injured/impaired, but would recover from the injury after some duration. During recovery, we assume that an injured ESA-listed sea turtle's ability to conduct important life functions (e.g., breeding, feeding) would be diminished, but that the animal would survive over time. We recognize there is uncertainty in this assumption as we do not have information available to determine how long an injured sea turtle would take to recover.

Sea turtles are not known to depend heavily on acoustic cues for vital biological functions (Nelms et al. 2016; Popper et al. 2014). As such, the likelihood that the loss of hearing in a sea turtle would impact its fitness (i.e., survival or reproduction) is low when compared to marine mammals, which rely heavily on sound for basic life functions. That said, it is possible that sea turtles use acoustic cues such as waves crashing, wind, vessel and/or predator noise to perceive the environment around them. If such cues increase survivorship (e.g., aid in avoiding predators, navigation), hearing loss may have effects on individual sea turtle fitness. TTS of sea turtles is expect to only last for several days following the initial exposure (Moein et al. 1994). Given this short period of time, and that sea turtles are not known to rely heavily on acoustic cues, we do not anticipate that single TTSs would have any impacts on the fitness of individual sea turtles.

PTS would permanently impair a sea turtle's ability to hear environmental cues, depending on the frequency of the cue and the frequencies affected by the hearing impairment. Given this longer time frame, we anticipate that at least some sea turtles that experience PTS may have a reduction in fitness either through some slight decrease in survivorship (e.g., decreased ability to hear predators or hazards such as vessels) or reproduction (e.g., minor effects to navigation that may reduce mating opportunities). It is important to note that the NAEMO modeling and classification of modeled effects from acoustic stressors, such as TTS and PTS, are performed in a manner as to conservatively overestimate the impacts of those effects. Acoustic stressors are binned and all stressors within each bin are modeled as the loudest source, necessarily overestimating impacts within each bin.

Behavioral and Physiological Stress Responses

Concurrent with the above responses, sea turtles are also expected to experience physiological stress responses. Stress is an adaptive response and does not normally place an animal at risk. Distress involves a chronic stress response resulting in a negative biological consequence to the individual. While all ESA-listed sea turtles that experience TTS, PTS, non-auditory injury and some behavioral responses are also expected to also experience a stress response, such responses are expected to be short-term in nature given that in most cases sea turtles are not expected to experience repeated exposure to explosives. As such, we do not anticipate stress responses would be chronic, involve distress, or have negative long-term impacts on any individual sea turtle's fitness. That said, long-term injuries such as non-auditory injuries and PTS may result in some prolonged stress that in combination with the injuries themselves, may function to reduce an individual sea turtle's fitness. If a sea turtle responds to an explosion, it could exhibit startle responses, leave the area, dive, or be disrupted during feeding or resting. There could be multiple responses to an explosion, and would likely be more significant the closer a turtle is to the detonation. Additionally, significant behavioral responses that result in disruption of important life functions are more likely to occur from multiple exposures within a longer period of time, which are not expected to occur during the Navy's use of explosives during their training and testing exercises.

The Navy will implement mitigation measures (described in Section 3.4.2) which include several Lookout scenarios with large exclusion zones. These measures would reduce the number of sea turtles that could be exposed to explosives by ensuring (as much as possible) that sea turtles are not present during exposure to this stressor. Additionally, the Navy will avoid conducting activities in the Cherry Point range from March through September within 3 NM of the estuarine inlet, and 1.6 m from the shoreline to avoid nesting beach areas; and no line charge testing will occur at night during this time.

In summary, explosives would result in mortality of approximately one loggerhead sea turtle per year on average, which would result in the removal of this sea turtle and its reproductive potential from the population. In addition, one Kemp's ridley, 12 loggerhead, and five leatherback sea turtles per year are expected to experience non-auditory injuries, which are expected to temporarily reduce the fitness of these individual sea turtles. Finally, four Kemp's ridley, five green, 73 loggerhead turtles, and 17 leatherback sea turtles per year are expected to experience PTS, which is anticipated to result in a reduction in fitness for at least some of these individual sea turtles, which could also result in loss of reproductive potential. While sea turtles are also expected to experience TTS, behavioral and physiological stress responses, these responses alone are not expected to have any long-term impacts nor affect the fitness of individual sea turtles. The explosives associated with the proposed action are expected to result in mortality and affect the fitness of individual sea turtles, but based on the low number of loggerhead individuals that could be killed per year, we do not anticipate that the use of explosives as proposed by the Navy would have measurable impacts at the population level for any ESA-listed sea turtle species.

During Navy training and testing activities, sea turtles could potentially experience take in the form of behavioral harassment from exposure to explosive detonations. We recognize that behavioral responses of turtles to acoustic stressors is poorly studied and very difficult to quantify. Based upon the Navy's estimates for explosives we anticipate 5,076 green sea turtles could exhibit behavioral responses and be harassed per year, and an additional percentage of the sea turtles that could experience TTS during ship shock trials (18 annually for large and 18 annually for small ship shock trails) would also be expected to exhibit more significant behavioral responses in conjunction with the TTS. For hawksbill sea turtles, 317 could be harassed annually, and up to 4 during small and large ship shock trials. Up to 6,656 Kemp's ridley sea turtles could be harassed, and a percentage of the 27 that could experience TTS during large and small ship shock trials could also be harassed. We anticipate up to 46,171 loggerhead sea turtles could be disturbed annually, and up to 622 loggerhead sea turtles that experience TTS during small and large ship shock trials could also be disturbed. Up to 3,297 leatherback sea turtles could also have their normal behaviors adversely affected with up to 384 leatherbacks also experiencing harassment in conjunction with TTS during small and large ship shock trials annually.

9.2.2.4 Vessel Strikes – Sea Turtles

The majority of the Navy's training and testing activities considered in this biological opinion involve vessel activity. The activities and locations that involve vessels (and in-water devices) has been thoroughly described in (Section 6.4) as well as provided in Appendix B (Activity Stressor Matrices) in the AFTT DEIS/OEIS (Navy 2017c) and Section 5.1.2.2.4.1 (Vessels and In-Water Devices) in the BA (Navy 2017a).

9.2.2.4.1 Potential Effects of Vessel Strikes

Within the action area, boat or vessel traffic is heaviest in the nearshore waters, near major ports, in the shipping lanes. Navy vessel traffic is primarily concentrated between the mouth of the Chesapeake Bay, Virginia and Jacksonville, Florida (Mintz 2012b). The Navy compared the amount commercial traffic to Navy vessel in these areas and determined that Navy vessel occurrence is two orders of magnitude lower (0.7 percent) than that of commercial traffic. The study also revealed that while commercial traffic is relatively steady throughout the year, Navy vessel usage within the range complexes is episodic, based on specific exercises being conducted at different times of the year (Mintz 2012b). In inshore waters (where vessel encounters with sea turtles may be higher), the Navy vessel use occurs regularly and is usually from small, high-speed vessels. These high-speed vessel movements in nearshore and inshore waters present a relatively higher risk for strike because of the higher concentrations of sea turtles in these areas and the difficulty for vessel operators see them and avoid collisions during high speed activities.

Sea turtles often congregate close to shorelines during the breeding season, where boat traffic is denser (Schofield et al. 2007; Schofield et al. 2010). Sea turtles, with the exception of hatchlings and pre-recruitment juveniles, spend a majority of their time submerged ((Renaud and Carpenter 1994; Sasso and Witzell 2006). Although, Hazel et al. (2007) demonstrated sea turtles preferred to stay within the three meters of the water's surface, despite deeper water being available. Any of the sea turtle species found in the action area can occur at or near the surface in open-ocean and coastal areas, whether resting, feeding or periodically surfacing to breathe. Therefore, all ESA-listed sea turtles considered in the biological opinion are at risk of vessel strikes.

Globally, there have been a few studies that focused solely on the interactions between sea turtles and marine vessels. While vessel strikes are a poorly-studied threat to sea turtles, they have the potential to be highly significant especially in nearshore turtle habitats as described above (Work et al. 2010b). Precise data are lacking for sea turtle mortalities directly caused by ship strikes; however, live and dead turtles are often found with deep cuts and fractures indicative of collision with a boat hull or propeller (Hazel et al. 2007; Lutcavage et al. 1997). Hazel and Gyuris (2006) studied the effect of recreational vessels on the mortality rates of sea turtles along the coast of Australia. Although sea turtles can move quickly, Hazel et al. (2007) concluded that vessel operators cannot rely on turtles to actively avoid being struck, for vessel speeds above 4 km/hour. Thus, sea turtles are not considered capable of moving out of the way of vessels moving at speeds greater than 4 km/hour. Most Navy vessels operate above these speeds in open water (Navy 2017a).

More large cruise and cargo ships transiting into coastal waters and nearshore habitat globally could result in increased sea turtle mortality due to collisions, habitat destruction, and pollution from the dumping of sewage, graywater, and garbage. Over two years, 130 sea turtles were killed by collisions with vessels along the coast of Queensland. Ship speed reductions and environmental protections would help prevent potential harm to sea turtle populations from shipping. Hazel et al. (2007) demonstrated that slowing ship speeds is beneficial to preventing vessel collisions with sea turtles.

In U.S. waters, vessel strike is an increasing concern, especially in the southeastern United States, where development along the coasts is likely to result in increased recreational boat traffic. In the U.S., the percentage of strandings that were attributed to vessel strikes increased from approximately 10 percent in the 1980s to a record high of 20.5 percent in 2004 (USFWS 2007). Many vessel strikes have been documented in southeast Florida with as many as 60 percent of stranded loggerheads displaying signs of propeller-related injuries (USFWS 2007). Twenty-three percent of sea turtle fatalities in the U.S. state of Georgia between 2004 and 2008 were attributed to impacts of ships and boats and their propulsion systems (Hazel et al. 2007). Fresh wounds on some stranded animals strongly suggests a vessel strike as the cause of death. The actual incidence of recovery versus death is not known, given available data.

All sea turtles must surface to breathe, and several species are known to bask at the surface for long periods. Therefore, they are particularly susceptible to being hit by a vessel transiting through areas where they may be resurfacing, resting or feeding at the surface. Vessel strikes can cause permanent injury or death from bleeding or other trauma, paralysis and subsequent drowning, infection, or inability to feed. Apart from the severity of the physical strike, the likelihood and rate of a turtle's recovery from a strike may be influenced by its age, reproductive state, and general condition at the time of injury. Much of what has been documented about recovery from vessel strikes on sea turtles has been inferred from observation of individual animals for some duration of time after a strike occurs. Sea turtle stranding networks that keep track of sea turtles that wash up dead or injured have consistently recorded vessel propeller strikes or collisions with vessel hulls (Hazel et al. 2007; Lutcavage et al. 1997). While research is limited on the relationship between sea turtles, ship collisions and ship speeds, it is clear that it is an area that needs attention and action.

The Navy also conducts propulsion testing as part of their activities involving vessels. This activity sometimes includes ships operating at speeds in excess of 30 knots, and although it occurs infrequently, it may pose a higher strike risk because of the high speeds which vessel operate. No high-speed vessel movements will occur within inshore waters for testing activities, but could occur during training. Propulsion testing would occur in the Northeast, Virginia Capes, Jacksonville, and Gulf of Mexico Range Complexes. As described in the section above, high speed vessel movements (greater than 10 knots) further increase the potential risk of vessel strikes by reducing the available reaction time of both the sea turtle and vessel operators to an impending strike. Sea turtle detection is likely based primarily on the animal's ability to see the oncoming vessel, which would provide less time to react to vessels traveling at speeds of about 10 knots (Hazel et al. 2007). Hazel et al. (2007) examined vessel strike risk to green sea turtles and suggested that sea turtles may habituate to vessel sound and are more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in eliciting responses (Hazel et al. 2007). Regardless of what specific stressor associated with vessels turtles are responding, they only appear to show responses (avoidance behavior) at approximately 10 m or closer (Hazel et al. 2007). This is a concern because faster vessel speeds also have the potential to result in more serious injuries (Work et al. 2010b). The data available make determining the amount of sea turtle mortality caused by vessel strikes difficult (Hazel et al. 2007; Lutcavage et al. 1997). The Navy will only conduct propulsion testing a few times per year, which may reduce the risk of vessel strike on sea turtles from vessels operating at high speeds.

Vessel use for Navy training and testing activities could result in physical disturbance and strikes to sea turtles, and would most likely occur in areas that overlap sea turtle habitats, especially in areas with high densities of sea turtles and high-speed vessel training activities. For training and testing exercises occurring in the deeper offshore waters of the action area, the species and age classes most likely to be impacted are hatchlings and pre-recruitment juveniles of all sea turtle species, all age classes of leatherback sea turtles, and occasionally adult loggerheads. The loggerhead sea turtle is the most abundant species in the Virginia Capes and Jacksonville Range Complexes and adults may be found foraging in waters as deep as 200 m (Hochscheid 2014; Rieth et al. 2011). The leatherback turtle is likely to be impacted by these activities, given its preference for open-ocean habitats and its foraging behavior at the surface and throughout the water column. Hatchlings and pre-recruitment juveniles of all sea turtle species may also occur in open-ocean habitats, where they reside among *Sargassum* mats. Sea turtles are expected to be highly dispersed in deeper offshore waters and, given the large area over which Navy vessels could potentially conduct training activities, the likelihood of co-occurrence is low in deeper offshore waters.

Within the action area, coastal foraging habitats exist for all sea turtle species over the continental shelf and within inshore waters. In these areas, juveniles, sub-adults, and adults of all species are at risk of vessel disturbance and strike because of the potential for higher concentrations of sea turtles and more frequent vessel movements in these areas. Near nesting beaches, hatchlings of all sea turtle species would also be present, but very briefly as they leave the nest, enter the water, and move to offshore areas to mature. Hatchlings would only be present a few months of the year between summer and fall in the action area from southern Virginia southward. Only green, Kemp's ridley, and loggerhead turtles are expected to be located in nesting areas as far north as Virginia. Leatherback turtles may nest as far north as North Carolina. Hawksbill turtles rarely nest in parts of Florida (USFWS 2013). Therefore, sea turtle species that occur over the continental shelf and in inshore waters (e.g., estuaries), would have a greater potential for impacts. This suggests that loggerhead turtles are likely the most at risk of vessel interactions in the open ocean and inshore waters, as this is the most abundant species in any of the Navy Range Complexes and inshore waters, such as Chesapeake Bay, that have the highest concentration of training activities involving vessel use. The Navy does not expect any seasonal difference in Navy vessel use to occur; therefore, impacts from vessels, including physical disturbance and potential for strike are dependent on each species' seasonal patterns of occurrence or degree of residency in the continental shelf and inshore water portions of the action area.

9.2.2.4.2 Exposure, Response, and Risk Analysis

Below we estimate the number of non-lethal and lethal vessel strikes of sea turtles that are expected to result from the proposed action. To calculate the total number of non-lethal vessel strikes in the action area, we reviewed the literature for reported occurrences of non-lethal vessel strikes. The occurrence of non-lethal vessel strike injuries observed in different study populations of sea turtles may provide a more accurate representation of the percentage of turtles struck by vessels and surviving than stranding data of dead or mortally wounded animals. Of the studies we reviewed that reported the percent of non-lethal vessel strikes in free-ranging sea turtles (Table 112), we determined that four studies best represent the expected strike risk in the action area. The study by Denkinger et al. (2013b) around San Cristobal Island was determined not appropriate to use in calculations for an overall percentage of sea turtles likely to be non-lethally struck by vessels since it appeared to be an outlier compared to the other estimates, and likely represents site specific information only applicable to similar areas in very close proximity to busy vessel ports.

Table 112. Summary of the literature reporting the percent of live sea turtles observed with vessel strike injuries.

Region	Species Research	Percent of Observed Animals with Vessel-Strike Injury	Source
Florida east coast	Foraging loggerhead sea turtles	2.8%	Norem (2005)**
Florida east coast	Foraging green sea turtles	0.6%	Norem (2005) **
Gabon	Nesting leatherback sea turtles	2.8%	Deem et al. (2006)
Isabela Island, Ecuador	Nesting green sea turtles	3.7%	Denkinger et al. (2013b)
San Cristobal Island*	Foraging green sea turtles' site near a busy port	19.4%	Denkinger et al. (2013b)
Cayman Islands	Juvenile hawksbill foraging sites	2%	Blumenthal et al. (2009)

**Data for San Cristobal region excluded from analysis.*
*** Percentage in original source presented as 1.9 percent across all species studied. Species specific percentage derived from data presented in original source, assuming a constant capture-recapture rate for all species.*

All of the above studies, except for Norem (2005), occur outside of the action area, and as such the associated non-lethal vessel strike percentages are influenced by different environmental conditions, sea turtle distributions, and vessel traffic. However, to our knowledge, they represent the best available data on non-lethal vessel strikes for the species considered in this biological opinion. From these data we assume that depending on the species, 1.9-3.7 percent of neritic juvenile and adult sea turtles (Epperly et al. 1995; NMFS 2011g) in the action area are likely to show evidence of a vessel strike at any given point in time. To calculate the number of neritic juveniles and adult sea turtles that may be struck and injured (non-lethal) by Navy vessels, we used the following equation:

Annual Number of Non-lethal Sea Turtle Strikes = (abundance of sea turtle species in action area) x (species-specific non-lethal vessel strike percentage based on Table 112) x (annual correction factor) x (percent of vessel traffic in the action area associated with the proposed action).

Each variable of the equation is further explained in the four steps below.

Step 1: we calculated the number of neritic juveniles and adult sea turtles in the action area using seasonal sea turtle density data provided by the Navy (Navy 2017e). While we recognize that these sea turtle density data are dated, to our knowledge they represent the best available data within the action area and were used by the Navy as part of the NMSDD for NAEMO modelling [although, see Winton et al. (2018) for more recent relative loggerhead sea turtle density estimates]. We consider these density estimates to only represent neritic juveniles and adult sea turtles greater than 30 cm in size (hereafter large sea turtles) because they are based on aerial surveys, corrected for sighting availability, which can only detect these larger sea turtles (Epperly et al. 1995; NMFS 2011f). In addition, species-specific density estimates are not available for all sea turtles. Specifically, the density data consist of spatial layers that represent the Kemp's ridley sea turtles, leatherback sea turtles, loggerhead sea turtles, and hardshell sea turtles, which consists of green, hawksbill, loggerhead, and Kemp's ridley sea turtles. As described previously the hardshell guild was developed for those animals that could not be identified to species during the original aerial surveys used to generate the density estimates.

Using these sea turtle density data provided by the Navy, we calculated seasonal abundance estimates for hardshell, Kemp's ridley, leatherback, and loggerhead sea turtles within the action area. The maximum total abundance calculated across seasons was used as the total abundance, since using the maximum accounts for seasonally increases in the population within the action area due to immigration. Given that in seasons other than that during which the maximum abundance occurs, sea turtle density within the action area would be less than the maximum, this approach is conservative. The results of these calculations can be seen in Table 113 below.

Table 113. Abundance of large (greater than 30-centimeter diameter) sea turtles in action area.

Species/Group	Abundance in Action Area
Hardshell sea turtles* (green, loggerhead, hawksbill, and Kemp's ridley sea turtles)	126,162
Kemps Ridley sea turtles	12,051
Leatherback sea turtles	64,056
Loggerhead sea turtles	175,725

**Olive ridley sea turtles are also part of the hardshell guild. However, as explained previously in this opinion, due to their rare, unlikely occurrence in the action area, Olive ridley sea turtles are not considered in this analysis.*

Step 2: we calculated the number of large sea turtles expected to have non-lethal vessel-strike injuries at any given point in time from all vessels within the action area (i.e., not just Navy vessels) by multiplying species-specific non-lethal vessel strike percentages by the abundance of each sea turtle species or group. For loggerhead sea turtles, a 2.8 percent was used based on the data in Norem (2005). For Kemp's ridley sea turtles and the guild of hardshell sea turtles, 2.3

percent was used based on the average of the four hardshell sea turtle percentages shown in Table 112 (excluding data from San Cristobal region as discussed above). Finally, for leatherback sea turtles, 2.8 percent was used based on the data provided by Deem et al. (2006). The resulting calculated numbers in column three of Table 114 provide an overall estimate of the number of sea turtles in the action area that will experience non-lethal vessel-strike injuries, but includes non-lethal vessel strike injuries that would occur over multiple years and from all vessels. To determine an annual number of non-lethal vessel strike injuries of sea turtles from Navy vessels, two further calculations were required as detailed below in steps three and four.

Step 3: we calculated the annual proportion of the total numbers of large sea turtles in the action area at any given time that are expected to have a non-lethal vessel strike injury. The numbers in the third column of Table 114 represent the total numbers of large sea turtles showing evidence of a non-lethal vessel strike at any given point in time, but they do not represent the number of strikes occurring each year that contribute to that total. That is, we would expect surviving turtles with injuries to be recounted for as many years as they remain alive, but individuals should only be counted once for the year in which the strike occurred when determine annual strike rates. Increases in sea turtle population numbers due to recruitment from younger age classes, and decreases in population numbers due to mortality can be used to discern the number of new injuries occurring annually. In order to estimate the number of non-lethal vessel strikes that occur annually, we applied survivorship probabilities in the population to estimate percent of sea turtles that leave the population each year through mortality and emigration, and those that will enter the population through recruitment from younger age classes and immigration. In taking this approach, we assume that the population is stable, the number of mortalities will be replaced with an equal number of individuals that are at risk of a non-lethal vessel strike, and that the percentage of the population with evidence of non-lethal vessel strikes is constant.

According to the recovery plans for loggerhead and Kemps' ridley sea turtles, annual survival probabilities for adults and neritic juveniles average 0.825 and 0.935 respectively, corresponding to an annual mortality rate of 17.5 percent for loggerhead and 6.5 percent for Kemp's ridley sea turtles. We do not have species-specific survivorship probabilities for the other species of sea turtles occurring in the action area, but we assume they are similar to loggerhead and Kemp's ridley sea turtles. Thus, we conservatively applied the higher loggerhead sea turtle mortality rate of 17.5 percent to green, leatherback, and hawksbill sea turtles (and hardshell sea turtles as a group). Using these mortality rates as a correction factor for population turnover, we calculated the estimated annual number of non-lethal vessel strikes (Table 114, fourth column).

Table 114. Non-lethal vessel strike injuries of large (greater than 30-centimeter diameter) sea turtles in the action area.

Species/Group	Percent with Non–lethal Vessel-Strike Injuries	Total Non-lethal Vessel Strike Injuries Observed in Population at Any Time Resulting from all Vessels	Annual Non-lethal Vessel Strike Injuries Resulting from All Vessels	Annual Non-lethal Vessel Strike Injuries Resulting from Navy Vessels
Hardshell sea turtles (green, loggerhead, hawksbill, and Kemp's ridley sea turtles)	2.3%	2,880	504	4
Kemps Ridley sea turtles	2.3%	275	18	1
Leatherback sea turtles	2.8%	1,794	314	3
Loggerhead sea turtles	2.8%	4,920	861	7

Step 4: we calculated the annual number of large sea turtles expected to experience non-lethal vessel strikes injuries due to Navy vessels as part of the proposed action by multiplying the estimated number of annual non-lethal vessel strike injuries resulting from all vessels (Table 114, fourth column) by 0.7 percent, which is the percent that Navy vessel traffic is estimated to make up of all vessel traffic in the action area (Mintz 2012a). The resulting number of large sea turtles expected to experience non-lethal vessel strikes injuries due to Navy vessels is given in the fifth column of Table 114. While the hardshell guild sea turtles includes hawksbill sea turtles, as discussed below for lethal vessel strikes, the available data indicate that vessel strikes of hawksbill sea turtles in the action area are infrequent, likely as result of their lower abundance in the action area compared to some of the other sea turtle species. Given this, and the low percentage of vessel traffic attributed to the Navy (0.7 percent), none of the three estimated annual non-lethal vessel strike injuries of hardshell turtles are expected to be of hawksbill sea turtles. As such, these three annual non-lethal vessel strike injuries could be of green, Kemp's ridley, or loggerhead sea turtles.

In order to evaluate the circumstances that result in mortality of sea turtles due to vessel strikes, we reviewed a study looking at the effect of vessel speed on lethal sea turtle injuries, as well as reported observations of sea turtle behavior in response to oncoming vessels. In tests of carapace damage resulting from vessel strikes of loggerhead sea turtles (Sapp 2010; Work et al. 2010a), physical models simulating the shape and strength of loggerhead carapaces were placed in the water and struck at idle speed (3.8 knots), sub-planing speed (7.6 knots), and planing speed (21.6 knots). This study showed that vessel strikes at idle speed resulted in lethal damage to the carapace 25 percent of the time. Vessel strikes at planing speed resulted in 100 percent lethal damage. At sub-planing speeds (7.6 knots), the resulting large bow wave helped push the animal out of the way, resulting in no contact with the carapace 38 percent of the time. Navy vessels may operate at different speeds, but some vessels reach high speeds that could cause death by blunt force trauma if the hull directly impacted a turtle as was tested in the study. The authors of the above studies noted that because the models were in a fixed position and directly hit in each test, the actual injury rate in free swimming sea turtles may be different due to the depth, orientation, and behavior of turtles in the wild. The studies also did not report the effect of vessel speed on propeller injury, and the results cannot be applied to all vessel-strike scenarios (Sapp 2010; Work et al. 2010a). According to Hazel et al. (2007), sea turtles cannot avoid boat collisions unless boats reduce their speed to 2.2 knots, increasing the likelihood that direct strikes on the carapaces from Navy vessels operating at fast speeds will be lethal. Sea turtles struck by propellers have a greater chance of surviving than those that incur blunt force on the carapace, which can expose the body cavity.

To estimate the number of lethal vessel strikes of sea turtles due to the proposed action, we relied on data from NMFS' Sea Turtle Stranding and Salvage Network (STSSN)[33], which consist of records of stranded sea turtles throughout action area (Maine-Texas). We queried the STSSN database for records of stranded sea turtles with evidence of vessel strike (definitive, probable, and possible, based on standard database codes). While we recognize that some vessel strikes may be postmortem, the available data indicate that postmortem vessel strike injuries are uncommon in stranded sea turtles. Based on data from off the coast of Florida, there is good evidence that when vessel strike injuries are observed as the principle finding for a stranded turtle, the injuries were both antemortem and the cause of death. Based on 194 necropsied sea turtles in various states of decomposition, for 180 individuals (92.8 percent) the cause of death or probable cause of death was vessel strike based on defined criteria which included evidence of timing in relation to death and severity of injury. For the remaining 14 individuals, the severity of injury was potentially fatal, but issues such as postmortem condition and other necropsy findings prevented confident attribution of cause of death. However, excluding those cases in which the timing of injury could not be determined (n=11, i.e., those in which confident examination based on the defined criteria was not possible), 98.4 percent of sea turtles with severe vessel strike injuries (i.e., non-healed, major injuries) had a cause of death or probable cause of death of vessel strike (B. Stacey, NMFS, personal communication to E. Patterson, NMFS; July 9, 2018). Thus, even for those STSSN records of stranded sea turtles with evidence of vessel strike that did not undergo a full necropsy, the available data indicate that in most cases the cause of death was vessel strike. Furthermore, as detailed below, in our analysis we do not assume that every stranded sea turtle with evidence of a vessel strike was killed by a vessel strike. We evaluated all available information associated with the stranding event and estimated maximum, minimum, and mid-point values to incorporate the uncertainty associated with determining whether the cause of death was indeed a vessel strike.

[33] https://www.sefsc.noaa.gov/species/turtles/strandings.htm

To estimate the annual number of sea turtles that are killed by vessel strikes within the action area, we used the most recent complete 10-year, fully verified dataset from the STSSN, which consisted of data from 2006-2015 for Texas through Virginia and data from 2000-2009 for Maryland through Maine. Using these data, we excluded cases in which a vessel strike was clearly not the cause of the stranding (as noted in the stranding event record) and those where the sea turtle was successfully released (i.e., the injury was non-lethal). Thus, only records in which the sea turtle was dead upon stranding, died soon after, or was deemed non-releasable (and thus was removed from the population) and that had had some evidence of vessel strike (definitive, probable, and possible) were considered in the analysis. Using these data, for each year we calculated the minimum annual number of observed lethal vessel strikes as the annual number of strandings with definitive and probable evidence of a lethal vessel strike, and then calculated the maximum annual number of observed lethal vessel strikes as the annual number of strandings with definitive, probable, and possible evidence of a lethal vessel strike. We then calculated the mid-point of these annual minima and maxima and graphed the resulting values by species and region to inspect for temporal increases and/or decreases.

Since there were no clear, consistent temporal changes in the number of observed lethal vessel strikes over the 10-year period for any species for either region (based in the mid-point values), we calculated the annual average number of observed lethal vessel strikes of each species for each region as the average of the 10 regional mid-point values. Following this, we summed the Texas-Virginia and Maryland-Maine averages for each species to obtain an estimate of the total annual average number of observed lethal vessel strikes of each sea turtle species for the entire action area, which was then rounded to the nearest integer (i.e., whole animal). Finally, since some records in the STSSN database were not identified to species, we attributed a portion of the total annual average number of observed lethal vessel strikes of "unknown" sea turtles to each "known" species based on the percentage each species made up of the estimated total annual average number of observed lethal vessel strikes of all species combined. The final estimates of the annual average number of observed lethal vessel strikes of each species can be seen in the second column of Table 115.

Table 115. Vessel strike mortalities of large (greater than 30-centimeter diameter) sea turtles in the action area.

Species	Annual Average Vessel Strike Mortalities (Observed)	Annual Average Vessel Strike Mortalities (Corrected)	Annual Lethal Vessel Strike Injuries Resulting from Navy Vessels
Green	266	1,565	11
Hawksbill	3	18	0
Kemps Ridley	104	612	4
Leatherback	21	124	1
Loggerhead	372	2,188	15

Importantly, the data in column two of Table 115 are only based on observed stranding records, which represent only a portion of the total at-sea mortalities of sea turtles within the action area. Although sea turtle stranding rates are variable, they usually do not exceed 20 percent of total mortality, as predators, scavengers, wind, and currents prevent carcasses from reaching the shore (Koch et al. 2013). Strandings may represent as low as five percent of total mortalities in some areas (Koch et al. 2013). Strandings of dead sea turtles from fishery interaction have been reported to represent as low as seven percent of total mortalities caused at sea (Epperly et al. 1996). Remote or difficult to access areas may further limit the amount of strandings that are observed. NRC (1990a) estimated boat-related mortalities of sea turtles numbered at about 400 per year for the U.S. Gulf of Mexico and Atlantic Coasts when one accounts for turtles that are not included in stranding records by assuming only 20 percent of sea turtles killed by vessels strand. Because of the low probability of stranding under different conditions, determining total vessel strikes directly from raw numbers of stranded sea turtle data would vary between regions, seasons, and other factors such as currents.

To correct the observed annual average vessel strike mortalities in Table 115 (column two) to include unobserved vessel strike mortalities, we relied on available estimates from the literature of the proportion of at-sea mortalities of sea turtles that are observed in stranding data within the action area. Based on data a reviewed in Murphy and Hopkins-Murphy (1989), only six of 22 loggerhead sea turtle carcasses tagged within the South Atlantic and Gulf of Mexico region were reported in stranding records, indicating that stranding data represent approximately 27 percent of at-sea mortalities. In comparing estimates of at-sea fisheries induced mortalities to estimates of stranded sea turtle mortalities due to fisheries, Epperly et al. (1996) estimated that strandings represented 7-13 percent of all at-sea mortalities.

Based on these two studies, both of which occurred within the action area, stranding data likely represent 7-27 percent of all at-sea mortalities. While there are additional estimates of the percent of at-sea mortalities likely to be observed in stranding data for locations outside the action area (e.g., Koch et al. 2013; Peckham et al. 2008), we did not rely on these since stranding rates depend heavily on beach survey effort, current patterns, weather, and seasonal factors among others, and these factors vary greatly with geographic location (Hart et al. 2006; Nero et al. 2013; Santos et al. 2018). Thus, based on the mid-point between the lower estimate provided by Epperly et al. (1996) of seven percent, and the upper estimate provided by Murphy and Hopkins-Murphy (1989) of 27 percent, we assume that the STSSN stranding data represent approximately 17 percent of all at sea mortalities. This estimate closely aligns with an analysis of drift bottle data from the Atlantic Ocean by Hart et al. (2006), which estimated that the upper limit of the proportion of sea turtle carcasses that strand is approximately 20 percent.

To estimate the annual average vessel strike mortalities corrected for unobserved vessel strike mortalities, we divided the number of observed annual average vessel strike mortalities in column two of Table 115 by 0.17. The resulting, corrected annual average number of vessel strike mortalities of each species within the action area (rounded to the nearest integer) are given in column three of Table 115. In using the 17 percent correction factor, we assume that all sea turtle species and at-sea mortalities are equally likely to be represented in the STSSN dataset. That is, sea turtles killed by vessel strikes are just as likely to strand and be recorded in the STSSN database (i.e., 17 percent) as those killed by other activities, such as interactions with fisheries, and the likelihood of stranding once injured or killed does not vary by species.

Finally, to estimate the annual average number of vessel strike mortalities that are likely to be due to the proposed action, we multiplied column three by 0.7 percent, the percent of vessel traffic in the action area estimated to be the result of the Navy. The final estimate of the annual number of lethal vessel strike injuries resulting from Navy vessel associated with the proposed action are given in column four of Table 115. Based on our analysis, the proposed action is expected to result in 11 lethal vessel strikes of large green sea turtles annually, four lethal vessel strikes of large Kemps ridley sea turtles annually, one lethal vessel strike of a leatherback sea turtle annually, and 15 lethal vessel strikes of loggerhead sea turtles annually. While the STSSN dataset included lethal vessel strikes of hawksbill sea turtles, given the low occurrence of these and the low percentage of vessel traffic within the action area attributed to Navy vessels, our calculations indicate that no lethal vessel strikes of hawksbill sea turtles are expected to result from the proposed action.

For oceanic juvenile sea turtles and hatchlings [considered to be sea turtles less than 30 cm in diameter, hereafter small sea turtles (Epperly et al. 1995; NMFS 2011g), there is very little information on the incidence of vessel strikes (lethal and non-lethal). While the STSSN dataset discussed above includes some records of stranded small sea turtles, these records comprise only a small proportion of the overall dataset (approximately seven percent) meaning the STSSN data primarily represent information on larger sea turtles. Given the lack of studies focused on vessel strikes of small sea turtles, we do not know if the strike rates of small sea turtles consistently differ from those of larger sea turtles; however, some studies of nearshore foraging areas show that older, benthic-stage juveniles are commonly struck (Blumenthal et al. 2009; Casale et al. 2012). Therefore, we conservatively assume vessel strikes are occurring in the surface-pelagic stage as well.

Because we lack estimates of small sea turtle densities across the action area, we are unable to quantitatively estimate the number of small, oceanic juveniles and nestlings (i.e., sea turtles less than 30 cm in diameter) vessel strikes in the same way we did for larger sea turtles. While Witherington et al. (2012) estimated the density of small green, Kemp's ridley, hawksbill, and loggerhead sea turtles in several locations in the North Atlantic and Gulf of Mexico, we determined that these density estimates are not applicable to the entire action area given the expansive geographic region in which the proposed action would occur. This is supported by the fact that the Navy density estimates for larger sea turtles vary substantially across latitudes within the action area, with density estimates in southern latitudes in some cases being approximately 100 times greater than those in northern latitudes. Small green, Kemp's ridley, and loggerhead sea turtles are often associated with *Sargassum* habitats in other locations, and we expect this association to hold true within the action area.

For example, Witherington et al. (2012) found that approximately 89 percent of post-hatchling and juvenile green, Kemp's ridley, loggerhead, and hawksbill sea turtles were within one meter of floating *Sargassum* based on surveys in the Gulf of Mexico and off the east coast of Florida, and no differences in this behavior were noted between locations. Even for those small turtles not within one meter of *Sargassum*, 78 percent of the time the closest object was still *Sargassum* and there was only one observation of a small sea turtle not associated with a floating object (within approximately 100 m). As such, the majority of green, Kemp's ridley, hawksbill, and loggerhead sea turtles less than 30 cm in diameter within the action are expected to be associated with *Sargassum* habitat. The association between small leatherback sea turtles and *Sargassum* habitat is less clear (Salmon et al. 2004; Wyneken and Salmon 1992). Therefore, we do not necessarily expect the majority of small leatherback sea turtles in the action area to be associated with *Sargassum* habitat, and instead assume they would be dispersed throughout the action area.

Gower and King (2011) used satellite imagery to estimate the seasonal extent of *Sargassum* in the North Atlantic and Gulf of Mexico, which provides some insight into where the majority of the small green, Kemp's ridley, hawksbill, and loggerhead sea turtles are likely to be found relative to the proposed action. In addition, loggerhead designated critical habitat includes areas expected to be covered by *Sargassum* at some point during the year (See Sections 7.1.5). While this habitat was designated only for loggerheads, it likely contains small sea turtles of all hardshell species regularly found within the action area. Based on the location of loggerhead *Sargassum* critical habitat and the areas identified by Gower and King (2011), a large proportion of the action area is expected to be covered by *Sargassum* at some point during the course of a year. We expect that the majority of small green, Kemp's ridley, hawksbill, and loggerhead sea turtles will be found in *Sargassum* habitat.

As part of the proposed action, the Navy proposes to use lookouts to observe floating vegetation, which would include *Sargassum*. If floating vegetation is observed, the Navy would avoid initiating activities until it passes, or move to another area avoiding the *Sargassum* rafts. While there is no explicit measure proposed to avoid vessels traveling through floating vegetation, which would decrease the chances of a ship strike of a small green, hawksbill, loggerhead, and Kemp's ridley sea turtles, we anticipate that in most cases the Navy will avoid traveling through *Sargassum*. This is because in many cases Lookouts would observe *Sargassum* and notify vessel operators to avoid it, and because depending on the density of the *Sargassum* and the size of the vessel, traveling through such floating vegetation may cause it to become entangled in the vessel's propeller, possibly causing it to malfunction or be damaged. Nonetheless, we are unable to quantitatively account for this mitigation.

Given that data are unavailable to estimate the incidents of vessel strikes (non-lethal and lethal) specifically for small sea turtles, we rely on information on vessel strikes of large sea turtles to estimate the relative exposure of small sea turtles to vessel strike from the proposed action.

For non-lethal vessel strikes, we relied on the same percentage of free swimming sea turtles with non-lethal vessel strike injuries given in Table 112, and as before, multiplied these be correction factors derived from survival probabilities from the Kemps ridley and loggerhead recovery plans to calculate annual non-lethal vessel strike rates as a percent of the small sea turtle populations within the action area. For Kemps ridley sea turtles, the most recent recovery plan estimated a survival probability for hatchlings and pelagic stage sea turtles of 0.318 and for small juveniles of 0.815. These survival probabilities correspond to mortality rates of 0.682 and 0.185 respectively, and an average for small Kemps ridley sea turtles of 0.4335. For loggerhead sea turtles, the most recent recovery plan estimated a survival probability for hatching and post-hatchlings of 0.7 and for oceanic juvenile of 0.9. These survival probabilities correspond to mortality rates of 0.3 and 0.1 respectively, and an average for small loggerhead sea turtles sea turtles of 0.2. As was done above with larger sea turtles, we relied on the more conservative mortality rate (here 43.35% from Kemps ridley sea turtles) for species that we lack survival probability estimates. Having applied these correction factors to the percentage of free swimming sea turtles with non-lethal vessel strike injuries given in Table 114 and multiplying the result by the 0.7 percent of vessel traffic attributed to the Navy, we estimate that 0.007 percent of the small hardshell (green, loggerhead, and Kemp's ridley) and Kemp's ridley, 0.008 percent of the small leatherback, and 0.004 percent of the small loggerhead sea turtle populations considered in this opinion will experience non-lethal vessel strikes injuries annually due to Navy vessels under the proposed action.

For lethal vessel strikes, we relied on the ratio of lethal to non-lethal vessel strikes estimates for adult sea turtles provided in Table 114 and Table 115 to derive annual lethal vessel strike rates as a percent of the small sea turtle populations within the action area. Assuming the lethal to non-lethal vessel strike ratio for large sea turtles also applies to small sea turtles, and relying on the annual non-lethal vessel strike rates as a percent of the small sea turtle populations within the action area calculated above, we estimate an annual lethal vessel strike rate (from all vessels) of 2.7 percent for green sea turtles (based on hardshell guild non-lethal vessel strike predictions), 4.2 percent for Kemp's ridley sea turtles, 0.4 percent for leatherback sea turtles, and 1.2 percent for loggerhead. Multiplying these by the 0.7 percent of the vessel traffic in the action area estimated to result from the Navy's proposed action, indicates that approximately 0.019 percent of small green sea turtles, 0.03 percent of small Kemp's ridley sea turtles, 0.002 percent of small leatherback sea turtles, and 0.009 percent of small loggerhead sea turtles within the action area will be killed by Navy vessel strikes annually. As with larger sea turtles, we do not expect any lethal vessel strikes of small hawksbill sea turtles to result from the proposed action.

In summary, sea turtle encounters with Navy vessels that result in injury or mortality are possible. Many sea turtles die as a result of being struck by moving vessels, although some injuries are likely not fatal, and individuals survive. It is generally not possible to determine what proportion of stranded sea turtle injuries were post or ante-mortem, there are also likely many unobserved vessel strikes of sea turtles. While the probability may be low in a given year, there is potential over time for the number of strikes we estimated for large and small sea turtles described above. The risk of collision between Navy surface vessels and submarines with green turtles, loggerhead turtles, Kemp's ridley turtles, and leatherback turtles is small compared to other vessels such as recreational and commercial vessels, during a given exercise or training and testing event, but possible over time. Within the action area, any large Navy vessels (greater than 18 m in length) in the offshore areas operate differently from commercial vessels. This is an important distinction to make in regard to the prevention of vessel strikes with sea turtles. For example, the average speed of large Navy ships ranges between 10 and 15 knots, and submarines generally operate at speeds in the range of 8 and 13 knots, while a few specialized vessels can travel at faster speeds (Navy 2017a). By comparison, most commercial vessels travel faster, with the full speed for a container ship typically being 24 knots (Bonney and Leach 2010). As mentioned above, sea turtles are not likely able to avoid vessels traveling faster than approximately 2.2 knots, and would therefore be unable to evade the vast majority of Navy vessels.

Although some mitigation measures the Navy proposes to implement for other activities may help reduce the risk (such as observations of floating debris and vegetation and not conducting activities in those areas, or moving away from areas where turtles likely congregate), these mitigation measures are not likely to appreciably reduce the risk from being struck by a moving vessel for the reasons discussed above. Therefore, NMFS expects collisions with Navy vessels to result in blunt trauma, other injuries, and lacerations of ESA-listed sea turtles. We also expect mortality of 11 large green, four large Kemps ridley, one leatherback, and 15 loggerhead sea turtles annually by Navy vessel strikes; and for 0.019 percent of small green, 0.03 percent of small Kemp's ridley, 0.002 percent of small leatherback, and 0.009 percent of small loggerhead sea turtles within the action area to be killed by Navy vessel strikes annually. For those species of sea turtles that sustain non-lethal injury, the severity of injury and time it take to recover are not possible to determine, but expected to have some type of fitness consequence. Therefore, we also assume some of these sea turtles would be compromised and sustain infection, have reduced foraging abilities, experience higher predation risks, or die some time later as a result of vessel strike injuries.

9.2.3 Fishes

Navy training and testing activities introduce a variety of stressors into the action area that are expected to result in adverse effects to ESA-listed fishes. Our effects analysis determined that acoustic stressors from pile driving and explosives, and vessel strikes, are likely to adversely affect these species. We do not have quantitative data to determine the number of ESA-listed fishes that could be impacted by these stressors, as density estimates for the action area are not available as they are for marine mammals and sea turtles. Instead, we provide relative percentages where possible, as with vessel strikes on sturgeon and in other cases use the ensonified zones in the water column that correlate with onset of injuries and behavioral disruption, or overlap of Navy activities with life history patterns of fish species.

9.2.3.1 Pile driving – Fishes

This section focuses on the potential effects of pile driving on ESA-listed fishes. Because the impulsive sound produced from pile driving and air guns have similar characteristics and associated effects on fishes, a general description of the research regarding these effects is included below. More detail regarding the likely effects on fishes from air guns used in the proposed action is in Section 9.1.3.1.5 above and for pile driving in Sections 9.2.3.1.2 and 9.2.3.1.4 below.

9.2.3.1.1 Potential Effects of Impulsive Sound Sources

Impulsive sounds such as those produced by seismic air guns and impact pile driving are known to affect fishes in a variety of ways, and have been shown to cause mortality, auditory injury, barotrauma and behavioral changes. As described in Section 6.1, impulsive sound sources produce brief, broadband signals that are atonal transients (e.g., not a continuous waveform). They are generally characterized by a rapid rise from ambient sound pressures to a maximal pressure followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures. For these reasons, they generally have an increased capacity to induce physical injuries in fishes, especially those with swim bladders (Casper et al. 2013a; Halvorsen et al. 2012b; Popper et al. 2014). These types of sound pressures cause the swim bladder in a fish to rapidly and repeatedly expand and contract, and pound against the internal organs. This pneumatic pounding may result in hemorrhage and rupture of blood vessels and internal organs, including the swim bladder, spleen, liver and kidneys. External damage has also been documented, evident with loss of scales, hematomas in the eyes, base of fins, etc. (e.g., Casper et al. 2012c; Gisiner 1998; Halvorsen et al. 2012b; Wiley et al. 1981; Yelverton et al. 1975a). Fishes can survive and recover from some injuries, but in other cases, death can be instantaneous, occur within minutes after exposure, or occur several days later.

Hearing impairment

Research is limited on the effects of seismic air guns on fishes, however some research on seismic air gun exposure has demonstrated mortality and potential damage to the lateral line cells in fish larvae, fry, and embryos after exposure to single shots from a seismic air gun near the source (0.01 to 6 m; Booman et al. 1996; Cox et al. 2012). Popper et al. (2005a) examined the effects of a seismic air gun array on a fish with hearing specializations, the lake chub (*Couesius plumbeus*), and two species that lack notable hearing specializations, the northern pike (*Esox lucius*) and the broad whitefish (*Coregonus nasus*), a salmonid species. In this study, the average received exposure levels were a mean peak pressure level of 207 dB re 1 μPa; sound pressure level of 197 dB re 1 μPa; and single-shot sound exposure level of 177 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 the northern pike and lake chub, and full recovery of hearing took place within 18-24 hours after sound exposure. Examination of the sensory surfaces of the showed no damage to sensory hair cells in any of the fish from these exposures (Song et al. 2008). Popper et al. (2006) also indicated exposure of adult fish to a single shot from an air gun array (consisting of four air guns) within close range (six meters) did not result in any signs of mortality, seven days post-exposure. Although non-lethal injuries were observed, the researchers could not attribute them to air gun exposure as similar injuries were observed in controlled fishes. Other studies conducted on fishes with swim bladders did not show any mortality or evidence of other injury (Hastings et al. 2008; McCauley and Kent 2012; Popper et al. 2014; Popper et al. 2007; Popper et al. 2005a).

McCauley et al. (2003) showed loss of a small percent of sensory hair cells in the inner ear of the pink snapper (*Pagrus auratus*) exposed to a moving air gun array for 1.5 hours. Maximum received levels exceeded 180 dB re 1 μPa^2-s for a few shots. 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. It is not known if this hair cell loss would result in hearing loss since TTS was not examined. Therefore, it remains unclear why McCauley et al. (2003) found damage to sensory hair cells while Popper et al. (2005a) did not. However, there are many differences between the studies, including species, precise sound source, and spectrum of the sound that make it difficult speculate what the caused hair cell damage in one study and no the other.

Hastings et al. (2008) exposed the pinecone soldierfish (*Myripristis murdjan*), a fish with anatomical specializations to enhance their hearing and three species without notable specializations: 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 in 16 ft (4.9 m) of water 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 following exposures. Based on the tests to date that indicated TTS in fishes from exposure to impulsive sound sources (air guns and pile driving) the recommended threshold for the onset of TTS in fishes is 186 dB SEL_{cum} re 1 μPa^2-s, as described in the 2014 *ANSI Guidelines*.

Elasmobranchs (Giant manta rays, oceanic whitetip sharks, scalloped hammerhead sharks and smalltooth sawfish), like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005b; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders (or any other air-filled cavity) and thus are unable to detect sound pressure (Casper et al. 2012c), and therefore are also likely less susceptible to non-auditory injuries compared to fish with swim bladders. Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper and Mann 2006; Casper and Mann 2009b; Casper et al. 2012c; Ladich and Fay 2013b; Myrberg 2001; Yan et al. 2003). Myrberg (2001) stated that sharks have demonstrated highest sensitivity to low frequency sound (40 to 800 Hz). Free-ranging sharks are attracted to sounds possessing specific characteristics including irregular pulsed, broadband frequencies below 80 Hz and transmitted suddenly without an increase in intensity, thus resembling struggling fish. These signals, some “pulsed,” are not substantially different from the air gun array signals. Myrberg et al. (1978) reported that silky shark withdrew 10 m from a speaker broadcasting a 150 to 600 Hz sound with a sudden onset and peak source level of 154 dB re: 1 μPa. These sharks avoided a pulsed low frequency attractive sound when its sound level was abruptly increased by more than 20 dB re: 1 μPa. Other factors enhancing withdrawal were sudden changes in the spectral or temporal qualities of the transmitted sound. The pelagic oceanic whitetip shark also showed a withdrawal response during limited tests, but less so than other species (Myrberg et al. 1978). These results do not rule out that such sounds may have been harmful to the fish after habituation; but the tests were not designed to examine that point. Thus, given their assumed hearing range, elasmobranchs are anticipated to be able to detect the low frequency sound from an air gun array if exposed, but TTS is not known to occur for these species.

Physiological Stress

Physiological effects to fishes from exposure to anthropogenic sound are increases in stress hormones or changes to other biochemical stress indicators (e.g., D'amelio et al. 1999; Sverdrup et al. 1994; Wysocki et al. 2006). Fishes may have physiological stress reactions to sounds that they can detect. For example, 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. Studies have demonstrated elevated hormones such as cortisol, or increased ventilation and oxygen consumption (Hastings and C. 2009; Pickering 1981; Simpson et al. 2015; Simpson et al. 2016; Smith et al. 2004a; Smith et al. 2004b). Although results from these studies have varied, it has been shown that chronic or long-term (days or weeks) exposures of continuous anthropogenic sounds can lead to a reduction in embryo viability (Sierra-Flores et al. 2015) and decreased growth rates (Nedelec et al. 2015). 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 loud and impulsive sound signals. Stress responses are typically considered to be brief (a few seconds to minutes) if the exposure is short or if fishes habituate or have previous experience with the sound**.** However, exposure to chronic noise sources may lead to more severe effects leading to fitness consequences such as reduced growth rates, decreased survival rates, reduced foraging success, etc. Although physiological stress responses may not be detectable on fishes during sound exposures, NMFS assumes a stress response occurs when other physiological impacts such as injury or hearing loss occur.

Some studies have been conducted that measure changes in cortisol levels in response to sound sources. Cortisol levels have been measured in fishes exposed to vessel noises, predator vocalizations, or other tones during playback experiments**.** Nichols et al. (2015a) exposed giant kelpfish (*Heterostichus rostratus*) to vessel playback sounds, and fish increased levels of cortisol were found with increased sound levels and intermittency of the playbacks. Sierra-Flores et al. (2015) demonstrated increased cortisol levels in fishes exposed to a short duration upsweep (a tone that sweeps upward across multiple frequencies) across 100 to 1,000 Hz. The levels returned to normal within one hour post-exposure, which supports the general assumption that spikes in stress hormones generally return to normal once the sound of concern ceases**.** Gulf toadfish (*Opsanus beta*) were found to have elevated cortisol levels when exposed to low-frequency dolphin vocalization playbacks (Remage-Healey et al. 2006). Interestingly, the researchers observed none of these effects in toadfish exposed to low frequency snapping shrimp "pops.", indicating what sound the fish may detect and perceive as threats. Not all research has indicated stress responses resulting in increased hormone levels. Goldfish exposed to continuous (0.1 to 10 kHz) sound at a pressure level of 170 dB re 1 μPa for one month showed no increase in stress hormones (Smith et al. 2004b). Similarly, Wysocki et al. (2007b) 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. Additionally, the researchers found no significant changes to growth rates or immune systems compared to control animals held at a sound pressure level of 110 dB re 1 μPa.

Masking

As described previously in this biological opinion, masking generally results from a sound impeding an animal's ability to hear other sounds of interest. The frequency of the received level and duration of the sound exposure determine the potential degree of auditory masking. Similar to hearing loss, the greater the degree of masking, the smaller the area becomes within which an animal can detect biologically relevant sounds such as those required to attract mates, avoid predators or find prey (Slabbekoorn et al. 2010). Because the ability to detect and process sound may be important for fish survival, anything that may significantly prevent or affect the ability of fish to detect, process or otherwise recognize a biologically or ecologically relevant sound could decrease chances of survival. For example, some studies on anthropogenic sound effects on fishes have shown that the temporal pattern of fish vocalizations (e.g., sciaenids and gobies) may be altered when fish are exposed to sound-masking (Parsons et al. 2009). This may indicate fish are able to react to noisy environments by exploiting "quiet windows" (e.g., Lugli and Fine 2003) or moving from affected areas and congregating in areas less disturbed by nuisance sound sources. In some cases, vocal compensations occur, such as increases in the number of individuals vocalizing in the area, or increases in the pulse/sound rates produced (Picciulin et al. 2012). Fish vocal compensations could have an energetic cost to the individual which may lead to a fitness consequence such as affecting their reproductive success or increase detection by predators (Amorin et al. 2002; Bonacito et al. 2001).

Behavioral Responses

In general, NMFS assumes that most fish species would respond in similar manner to both air guns and impact pile driving. As with explosives, these reactions could include startle or alarm responses, quick bursts in swimming speeds, diving, or changes in swimming orientation. In other responses, fish may move from the area or stay and try to hide if they perceive the sound as potential threat. Other potential changes include reduced predator awareness and reduced feeding effort. The potential for adverse behavioral effects will depend on a number of factors, including the sensitivity to sound, the type and duration of the sound, as well as life stages of fish that are present in the areas affected.

Fish that detect an impulsive sound may respond in "alarm" detected by Fewtrell (2003), or other startle responses may also be exhibited. The startle response in fishes is a quick burst of swimming that may be involved in avoidance of predators. A fish that exhibits a startle response may not necessarily be injured, but it is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment. However, fish do not exhibit a startle response every time they experience a strong hydroacoustic stimulus. A study in Puget Sound, Washington suggests that pile driving operations disrupt juvenile salmon behavior (Feist et al. 1992). Though no underwater sound measurements are available from that study, comparisons between juvenile salmon schooling behavior in areas subjected to pile driving/construction and other areas where there was no pile driving/construction indicate that there were fewer schools of fish in the pile-driving areas than in the non-pile driving areas. The results are not conclusive but there is a suggestion that pile-driving operations may result in a disruption in the normal migratory behavior of the salmon in that study, though the mechanisms salmon may use for avoiding the area are not understood at this time.

Because of the inherent difficulties with conducting fish behavioral studies in the wild, data on behavioral responses for fishes is largely limited to caged or confined fish studies, mostly limited to studies using caged fishes and the use of seismic air guns (Lokkeborg et al. 2012). In an effort to assess potential fish responses to anthropogenic sound, NMFS has historically applied an interim criteria for onset injury of fish from impact pile driving which was agreed to in 2008 by a coalition of federal and non-federal agencies along the West Coast (FHWG 2008). These criteria were also discussed in Stadler and Woodbury (2009), wherein the onset of physical injury for fishes would be expected if either the peak sound pressure level exceeds 206 dB (re 1 μPa), or the SEL_{cum}, (re 1 μPa^2-s) accumulated over all pile strikes occurring within a single day, exceeds 187 dB SEL_{cum} (re 1 μPa^2-s) for fish two grams or larger, or 183 dB re 1 μPa^2-s for fishes less than two grams. The more recent recommendations from the studies conducted by Halvorsen et al. (2011a), Halvorsen et al. (2012b), and Casper et al. (2012c), and summarized in the 2014 *ANSI Guidelines* are similar to these levels, but also establishes levels based upon fish hearing abilities, the presence of a swim bladder as well as severity of effects ranging from mortality, recoverable injury to TTS. The interim criteria developed in 2008 were developed primarily from air gun and explosive effects on fishes (and some pile driving) because limited information regarding impact pile driving effects on fishes was available at the time. For these reasons, the interim criteria are broadly applied to other impulsive sound sources such as air guns.

9.2.3.1.2 Exposure Analysis – Pile driving

As described in Section 6.1.6, impact pile driving and vibratory pile removal would occur during construction of an Elevated Causeway System. This is a temporary pier that will be constructed in sandy, shallow coastal waters at 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.

Pile driving for the Elevated Causeway System training would occur in shallower water and sound could be transmitted on direct paths through the water, be reflected at the water surface or bottom, or travel through bottom substrate. The impact wave travels through the steel pile at speeds faster than the speed of sound in water, producing a steep-fronted acoustic shock wave ("mach wave") in the water (Reinhall and Dahl 2011). In general, softer substrates absorb the sound better than hard substrates, thus, pile driving in softer substrates does not typically produce the louder sound signals that driving in hard substrate would. Soft, wetted substrates, may increase ground-borne transmission, meaning a sound wave could propagate further away from the source through the substrate. If ground-borne transmission sound reenters the water column, the intensity and amplitude of the sound wave would likely be lower than the sound wave traveling from the source through the water column and not likely to cause injury but could result in disturbance.

Of the ESA-listed species considered in this section of the biological opinion, Atlantic sturgeon and giant manta rays could be exposed to sound produced by impact pile driving and vibratory pile extraction activities during the construction and removal phases of the Elevated Causeway System. Potential effects to shortnose sturgeon from pile driving were discussed in Section 7.1.4.

In general, the acoustic frequency of the sound produced during piles installation (and removal) is generally below 1,000 Hz. The size, type, sound source levels of piles anticipated to be installed for construction of the Elevated Causeway are provided in Table 116.

Table 116. Underwater sound levels for elevated causeway system pile driving and removal (Navy 2017a).

Pile Size and Type	Method	Average Sound Levels at 10 m (SEL per individual pile)
24-in. Steel Pipe Pile	Impact[1]	192 dB re 1 μPa SPL rms 182 dB re 1 $\mu Pa^2 s$ SEL (single strike) 211 dB re 1 re 1 μPa SPL peak
24-in. Steel Pipe Pile	Vibratory[2]	146 dB re 1 μPa SPL rms 145 dB re 1 $\mu Pa^2 s$ SEL (per second of duration)

[1] Illingworth and Rodkin (2016), [2] Illingworth and Rodkin (2015)
Notes: in. = inch, SEL = Sound Exposure Level, SPL = Sound Pressure Level, rms = root mean squared, dB re 1 μPa = decibels referenced to 1 micropascal

As previously described, the Elevated Causeway may require up to 119 supporting piles. No more than six piles are expected to be driven within a 24-hour period thus a total of 20 days of intermittent impact pile driving is expected to occur. The Navy estimates each pile could take about 15 minutes to drive, requiring between 35 to 50 strikes per minute. Each pile could require from 525 to 750 strikes per pile, with between 3,150 to 4,500 strikes total in a 24-hour period. When training events that use the Elevated Causeway are complete, the pier would be dismantled and removed, requiring pile extraction with a vibratory hammer. The Navy anticipates this will take approximately 10 days and up to 12 piles will be removed during each 24-hour period. Each pile will require approximately six minutes to remove, for a total of 72 minutes per day. Pile driving is expected to occur over the course of up to 30 days (20 days for construction and 10 days for removal) at either location in any given year.

As with air guns, the impulsive sound produced from pile driving with an impact hammer is also known to cause auditory impairment[34] and non-auditory injuries (i.e., barotrauma) in fishes. Barotraumas such as ruptured swim bladders, ruptured blood vessels, and hemorrhaging of other gas-filled organs, have been reported in fish exposed to a large number of simulated impact pile driving strikes. Similarly, dead or injured fish have been collected on site during actual pile driving events. Injuries have been observed both externally and internally. Loss of scales, external hematomas, and distended abdomens have been recorded, indicative of ruptured swim bladders or other internal organ damage.

Controlled laboratory studies exposed fishes to cumulative sound exposure levels up to 219 dB re 1 μPa^2-s (Casper et al. 2013a; Casper et al. 2013b; Casper et al. 2012c; Halvorsen et al. 2011a; Halvorsen et al. 2012b). Although single strike peak sound pressure levels were also measured during these experiments, injuries were only observed during exposures to multiple strikes, which is what commonly occurs during most pile driving events. However, there is the potential to have aberrant or high peak single peak pressure levels that can injure or kill fish. Although species with and without swim bladders were included in these studies, the researchers demonstrated that the majority of fish that sustained injuries were those with swim bladders. Halvorsen et al. (2011a) also conclude that the presence of a swim bladder as well as the type of a swim bladder may also determine the degree of injury a fish sustains from these sound exposures. For example, physostomous fishes (e.g. salmon and sturgeon) have an open duct connecting the swim bladder to their esophagus and may be better able to adjust the amount of gas in their body by gulping or releasing air in a more rapid manner than physoclistous fishes. Physoclistous fish do not have this connection and must diffuse or regulate gas pressure in the swim bladder by special tissues or glands. Lake sturgeon (*Acipenser fulyescens*), a physostomous fish, was found to be less susceptible to injury from impulsive sources than Nile tilapia (*Oreochromis niloticus*), a physoclistous fish (Halvorsen et al. 2012a).

Another factor regarding a fish's susceptibility to injury related to the swim bladder is its state of buoyancy during exposure. In the Halvorsen et al. (2011a) and Halvorsen et al. (2012b) studies, neutral buoyancy was determined in the fishes prior to exposure to the simulated pile driving. Establishing the state of buoyancy for fishes in the wild is not possible, so their response to exposure at the same sound source levels may vary. No mortalities occurred during these experiments and recovery was generally observed to occur within a few days. Other experimental data suggests that fish larvae exposed to pile driving at cumulative sound exposure levels up to 206 dB re 1 μPa_2-s and peak sound pressure levels of 210 re 1 μPa are not susceptible to mortality (Bolle et al. 2012).

Another study obtained similar results as described above, but in caged fish exposed to live pile driving operations (Debusschere et al. 2014). Caged juvenile European sea bass (*Dicentrarchus*

[34] Research regarding hearing loss in fishes from exposure to impulsive sound sources is described in section XX and above under effects of air guns.

labrax) showed no differences in mortality between control and experimental groups at similar levels tested in the experiments described by Halvorsen and Casper in the paragraph above (sound exposure levels up to 215 to 222 dB re 1 μPa^2-s) and many of the same types of injuries occurred.

In an investigation of another impulsive source, Casper et al. (2013a) 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 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 fishes 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. For these reasons, the researchers speculated that injury might occur prior to signs of hearing loss or TTS. This is why understanding at what levels the onset of injury occurs is important.

Vibratory hammers produce a non-impulsive, continuous sound, as such are considered less harmful for fishes than impact hammers. Although it is possible for fish to be injured or killed from exposure to continuous sound sources, the exposure time would be a much longer duration than those that will occur for vibratory hammer pile extraction proposed by the Navy. The duration of pile extraction the Navy proposes for pile removal is not likely to cause any injury or hearing impairment on fishes, but could elicit some type of behavioral response if a fish detects the sound. For these reasons the effects from impact hammering of piles is the primary consideration here for analyses of potential adverse effects on fishes.

The following section provides calculated distance to the range to effects for fishes exposed to impact pile driving. Ranges are calculated based on the 2014 *ANSI Guidelines* (See Section 2.3). The Navy based their calculations on the assumption that pelagic species of fishes would be able to move away or quickly from the pile driving sound source and therefore not sustain cumulative exposures for an entire pile driving duration. Therefore, the Navy calculated ranges to effect for these species are estimated based on an average of 35 strikes per minute, for a cumulative exposure time of only one minute. These distances are provided in Table 117.

Table 117. Range to effect from impact pile driving for 35 strikes (1 minute) (Navy 2017a).

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

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 below the provided range.

In this minimum exposure scenario, mortality or injury could occur in fishes with swim bladders exposed to impact pile driving at distances less than 17 m from the source. These fishes could also experience hearing loss at distances less than 57 m.

The Navy acknowledged that fish do not always move away from pile driving sound, and may remain in the vicinity of the activities. For these reasons, they also provided calculations for range to effects based upon an entire day's pile driving activity. Similarly, NMFS conservatively assumes fishes do not always move away from the sound source and may stay in the area during pile driving activities and, therefore, could accumulate sound levels for a longer duration during a pile driving event. This would be particularly true for fish that have high site-fidelity. For this reason, NMFS completed additional calculations and potential ranges to effects based upon the minimum and maximum pile strikes it may take to drive all six piles in the given day. These include daily total of between 3,150 (minimum) and 4,500 (maximum) number of pile strikes to seat all piles within a 24-hour period. These strike numbers are based upon the Navy's estimates for typical range of strikes required to drive the 24 inch steel pipe piles during previous Navy pile driving activities. NMFS also has established an "effective quiet" SEL for pile driving analysis which is included in our calculations. Effective quiet assumes when the received SEL from an individual pile strike is below a certain level, then the accumulated energy from multiple strikes would not contribute to injury, regardless of how many pile strikes occur. This is determined to be 150 dB (re: 1 μPa^{2}-s). Therefore, effective quiet establishes a limit on the maximum distance from the pile where injury to fishes is expected. Beyond this distance, no physical injury is expected, regardless of the number of pile strikes. However, the severity of the injury can increase within this zone as the number of strikes increases.

The respective distances to these ranges are provided below in Table 118.

Table 118. Range to effects from impact pile driving for 3,150 and 4,500 strikes per day.

Fish Hearing Group	*Onset of Mortality*		*Onset of Injury*		*TTS*	*Behavior*
	SEL_{cum}	SPL_{peak}	SEL_{cum}	SPL_{peak}	SEL_{cum}	*RMS*
	Range to Effects Minimum of 3,150 Strikes (meters)					
Fishes without a swim bladder	8	8	11	8	NR	3511
Fishes with a swim bladder not involved in hearing	40	17	70	17	755	3511
Fish Hearing Group	*Range to Effects maximum of 4,500 Strikes (meters)*					
Fishes without a swim bladder	9	8	14	8	NR	3511
Fishes with a swim bladder not involved in hearing	50	17	87	17	870	3511

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 below the provided range.

Without knowing the exact timing between subsequent piles being installed within a given day, we assume that there will be a relatively short time between each pile being driven. For this reason, unless a break of 12 hours or longer occurs between pile driving events, NMFS calculates all piles driven in a given day to determine the isopleths for each fish threshold. Based on the onset of injury criteria and the proposed pile driving scenarios, the maximum range any Atlantic sturgeon could be adversely affected from pile driving is within 870 m of the pile[35]. Severity of injury would likely increase closer to the pile. Mortality is more probable within 50 m of the pile. Some fish could sustain lethal and non-lethal injuries within 87 m of the pile and TTS anywhere within those zones out to the 870-m distance. Any fish located within these zones that are not injured or that do not experience hearing impairment could also exhibit changes in behavior. These fish could be exposed for up to 30 days (20 days for construction and 10 days for pile removal) at either location in any given year.

As distance from the pile increases, sound pressure levels decrease and the potential harmful effects to fish also decrease. Hence, the distance to reach the 150 dB rms corresponding to sub-injurious sound levels (i.e., non-lethal, behavioral responses) is not expected to extend beyond a 3,511 m radius from any pile driving event. This larger area defines the total area of impact expected from pile driving during Navy construction of the Elevated Causeway.

Atlantic Sturgeon

All five DPSs of Atlantic sturgeon could be present during pile driving activities. These fish could be exposed to sound transmitted through the water column and through the substrate during impact hammer pile driving, and vibratory hammer pile removal. Specifically, exposures could occur in either Joint Expeditionary Base Little Creek-Fort Story, Virginia, or Marine Corps

[35] No ESA-listed fishes are expected to be present smaller than two grams during any pile driving event.

Base Camp Lejeune, North Carolina. Although adult and sub-adult Atlantic sturgeon travel up and down the coast during migration and could be exposed to pile driving activities in nearshore areas, the endangered Chesapeake, New York Bight, and Carolina DPSs would have the highest risk of exposure compared to other DPSs. This is primarily due to known species' distributions and habitat within these portions of the action area that overlap with construction of the Elevated Causeway.

Giant Manta Ray

Giant manta rays have the potential to be exposed to sound in the water column as well as transmitted through the substrate during impact hammer pile driving and vibratory hammer pile removal. Similar to Atlantic sturgeon, these exposures could occur in either Joint Expeditionary Base Little Creek-Fort Story, Virginia, or Marine Corps Base Camp Lejeune, North Carolina. Giant manta rays largely occur in offshore areas but occasionally visit coastal areas where marine upwelling occurs. However, the likelihood of this species being impacted by pile driving activities is considered extremely low. Giant manta rays are pelagic filter feeders and continually swimming, therefore on the remote chance that one enters the zones where exposure to pile driving sound levels is possible, they are not expected to remain within the vicinity nor get close enough to the pile where injurious sound levels are expected to occur. For these reasons, giant manta rays are more likely to experience brief periods of masking, physiological stress or brief behavioral reactions and not sustain physical injury or hearing impairment. These responses are expected to return to normal, and therefore the potential exposure of giant manta rays to pile driving sound is considered insignificant.

9.2.3.1.3 Response Analysis – Pile Driving

Because we do not know the exact number of fishes that could be exposed due to lack of density information, nor time of year the activities could take place, we cannot quantify how many individual Atlantic sturgeon will be present during pile driving. Therefore, we must rely on the potential sound levels within each zone described above to conduct a conservative, qualitative assessment. Fishes located within a closer proximity to the pile are more likely to sustain injury or TTS, and some could be killed. Although pile driving with an impact hammer has been associated with the mortality of a white sturgeon during the 2002 construction of the Benicia-Martinez Bridge in California, those piles were very large (96 inch) compared to the piles proposed for use by the Navy. Nonetheless, it may be possible for sturgeon to be injured from pile driving exposure. No permanent hearing damage would occur for any fishes that may experience TTS, but the degree of TTS is likely dependent on the duration of exposure, which would also affect how long it takes a fish to recover from TTS. Recovery could take from minutes to a few weeks.

We assume any fish that are able to detect the pile driving sound could exhibit a range of different behavioral responses. The observed behavioral changes include startle responses, bursts in swimming speeds, or changes in direction, and physiological responses such as increases in stress hormones. Other potential changes could include reduced predator awareness and reduced feeding efforts. The potential for adverse behavioral effects will depend on a number of factors, including the fish's sensitivity to sound, the type and duration of the sound, and proximity to the sound. Adverse or more significant behaviors are likely to occur closer to the pile driving sound, and would be expected to decrease further away from the pile sound source. Behavioral changes could be demonstrated by "agitation" of fishes, indicated by a change in swimming behavior, or "alarm" as detected by Fewtrell (2003). Startle responses or quick burst of swimming speed may also be exhibited. A fish that exhibits a startle response may not necessarily be injured, but it is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment. Fish do not exhibit a startle response every time they experience a strong hydroacoustic stimulus. In some cases, fish may detect the sound and leave, but may also return quickly or mill around in the ensonified area and sustain a greater accumulation period of sound exposure.

Because Atlantic sturgeon may occur along the substrate, are known to be capable of detecting vibration through the substrate, and may behave similarly to demersal fishes in nearshore areas, there is the potential for Atlantic sturgeon to be exposed to pile driving for longer durations compared to pelagic species. However, it is unlikely that exposed individuals would move closer to the source if detected, and they may move away and not accumulate an entire day's sound exposure for any given pile event. As such, the likelihood of injury is smaller compared to the potential for sturgeon to experience brief periods of masking, physiological stress or behavioral reactions. We do not know with any degree of certainty that a fish will leave the area and not return during subsequent pile driving activity and accumulate a higher degree of sound energy. In some instances, Atlantic sturgeon may habituate to the sound if they are located further away or they are more focused on feeding or other behaviors. Vibratory pile extraction would not be anticipated to result in any injuries to fishes due the maximum duration anticipated to occur each day, but as with impact hammering, could induce physiological stress, or behavioral reactions if a sturgeon detects the sound via the water column or substrate and is disturbed or displaced by it.

9.2.3.1.4 Risk Analysis – Pile Driving

NMFS has assumed a worst-case scenario in the discussion above. However, the effects from pile driving on fishes could be reduced due to other factors during pile driving of the Elevated Causeway. Because the pier will be constructed from the shoreline seaward, piles will be installed in varying water depth, albeit shallower water. Sound is less likely to propagate for large distances in shallow waters than it would in deeper, offshore marine waters. Plus, the sandy substrate where the elevated causeway system will be installed is typically an easier medium to drive piles and is not expected to cause some of the aberrant, high single peak values or higher accumulated sound levels that would occur if driving into rock or other hard bottom substrates. Additionally, wave action could also help to attenuate sound from propagating to great distances from the pile, although the Navy did base their calculations on a previously measured transmission loss for a similar structure and location. The location of the Elevated Causeway could also reduce the number of fish expected to be within close proximity to pile driving since these structures are built from the beach extending seaward in areas influenced by waves and human disturbance. These reasons, coupled with the potential impacts described above, make it likely that only a very small number of Atlantic sturgeon would be present and injured or killed.

Behavioral and stress responses are expected to be short-term, infrequent, and localized based on the low annual number of activities and short duration of a pile driving event in any given year. Therefore, long-term consequences are not expected to occur for populations of Atlantic sturgeon from pile driving (and removal).

9.2.3.2 Explosives – Fishes

Within the action area, explosives used in training and testing activities proposed by the Navy would be concentrated in the Virginia Capes Range Complex, followed in descending order by number of activities in the Jacksonville, Navy Cherry Point, Gulf of Mexico, Northeast, and Key West Range Complexes, and the lower Chesapeake Bay (Navy 2017a), and 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 SFOMF (Navy 2017a). For most of these activities, the use of underwater detonations and explosive munitions would typically occur more than 3 NM from shore in waters greater than 200 ft deep. 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. In addition, some mine warfare and demolition activities could also occur in nearshore, shallow waters. Within these areas, the Navy will implement mitigation measures to avoid impacts from explosives on seafloor resources within designated mitigation areas throughout the action area, which would avoid or minimize potential impacts on fishes that inhabit coral reefs, hard bottom substrates, or shipwrecks (Navy 2017a).

Small ship shock trials could take place during any season within the deep offshore water of the Virginia Capes Range Complex, and within the Jacksonville Range Complex during the spring, summer or fall. These trials would occur up to three times over a 5-year period. Large ship shock trials 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. However, these large trials would only occur once over each five year period of training and testing. Testing activities that involve the use of explosives would differ in number and location from training activities. However, the types and severity of impacts would not be discernible from those described for training activities. The exception to this includes ship shock trials which are specific to testing activities and would result in larger ranges to mortality or injury for fishes due to the size of the charge.

9.2.3.2.1 Exposure Analysis – Fishes

NMFS considers explosive exposure the stressor that poses the highest risk of injury and mortality for ESA-listed fishes in the action area. In the action area, all ESA-listed fishes could be exposed to energy and sound from underwater and in-air explosions associated with proposed activities. The general categories of the explosives, such as size and number of detonations, are described in the Section 6.2 of this biological opinion. The Navy also provided detailed descriptions of this stressor in Appendix A (Navy Activity Descriptions) in the AFTT DEIS/OEIS (Navy 2017c).

The effects on species from exposure to these explosives may result in mortality, non-lethal injury, temporary loss of hearing, physiological stress, masking, and behavioral responses. Effects on species is determined by the specific threshold criteria the Navy used based upon a fish's hearing sensitivity (e.g. hearing specializations and sound detections of the specific source) and physical characteristics of the species (e.g. presence and type of swim bladder). Along with these, several other factors influence the potential degree of impact, such as level and duration of sound, where in the sound field the fish is in proximity to the source, as well as the current condition and attentional focus of the fish.

NMFS does not currently have "formal" criteria established for explosives thresholds and effects on fishes, and in most cases bases interim thresholds upon the lowest level of sound where onset of injury may occur. In general, this lowest level (SEL_{cum}) correlates with TTS and therefore typically establishes the starting point where a spectrum of effects may occur for fishes ranging from minor, recoverable injury, TTS, to lethal injury and mortality. The Navy used a similar approach, and based the mortality threshold used for analyses upon the lowest pressure levels supported in the scientific literature (Hubbs and Rechnitzer 1952b). This is consistent with other NMFS explosives analyses for fishes as well as the with the recommendation described more recently in the 2014 *ANSI Guidelines* (Popper et al. 2014). Historically, most research regarding fish and explosives only utilized the peak pressure metric to correlate a percentage mortality, therefore there is very limited data currently available for explosives and fishes that have both the peak and SEL pressure metrics established for fishes. The 2014 *ANSI Guidelines* provide a conservative peak value for mortality, which allows for calculation of a maximum lethal impact range for fishes exposed to underwater detonations.

As previously described for impulsive sound sources, and effects on fishes, the acoustic criteria (Section 2.3) NMFS uses were developed for impact pile driving (FHWG 2008) wherein the onset of physical injury would be expected if either the peak sound pressure level exceeds 206 dB re 1 μPa, or the SEL_{cum}, accumulated over all impulses (e.g. pile strikes) generally occurring within a single day, exceeds 187 dB re 1 μPa^2-s for fish two grams or larger, or 183 dB re 1 μPa^2-s for smaller fish. However, at the time the criteria were developed, there was very limited data on impact pile driving. Therefore, the criteria were largely derived from data taken from explosives (Yelverton et al. 1975; converted to SEL by Hastings and Popper 2005b) and seismic air guns (Popper et al. 2005a). These criteria hey have been applied to a broad range of impulsive sound sources (both air guns and explosives) in order to provide reasonable means for assessment of impacts on fishes from these type of sound sources. Similarly, due to the lack of detailed data for onset of injury in fishes exposed to explosives, thresholds from impact pile driving exposures are used as a proxy for this analysis of explosives (Halvorsen et al. 2012a; Halvorsen et al. 2012b; Halvorsen et al. 2011b) which is also consistent with the *ANSI Guidelines* (Popper et al. 2014), wherein dual metric sound exposure criteria are utilized to estimate injury from exposure to explosives (See Table 119 below).

The Navy used the criteria provided in the 2014 *ANSI Guidelines*, which also divides fish according to presence of a swim bladder and whether the swim bladder is involved in hearing.

Because we have no way of estimating the abundance and assemblage of fishes with or without these characteristics, NMFS assumes the zone of impact would encompass the distance it would take for the sound wave to reach the criteria for the most sensitive fish species and onset of the lowest level of injury along the injury continuum, in this case would be either >207 dB peak re 1 μPa, or >186 dB SEL_{cum} dB re 1 μPa^2-s. However, for a more accurate assessment of the potential range and severity of effects, we will consider all three distances the Navy modeled which includes criteria for mortality, onset of injury, and TTS. These distances are based upon the injury criteria and explosive characteristics the Navy will use as part of the proposed action.

Table 119. Sound exposure criteria for mortality, injury, and TTS from explosives (Navy 2017a).

Fish Hearing Group	Onset of Mortality	Onset of Injury		TTS NC
	SPL_{peak}	SEL_{cum}	SPL_{peak}	SEL_{cum}
Fishes without a swim bladder	229	> 216	> 213	NC
Fishes with a swim bladder not involved in hearing	229	203	> 207	> 186

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. Notes: TTS = Temporary Threshold Shift. NC = no criteria, > indicates that the given effect would occur above the reported threshold.

Density data for ESA-listed fish species within the action area are not currently available. Therefore, it is not possible to estimate the total number of individual fish that may be affected by activities using explosives. In order to estimate the longest range at which a fish may be killed instantaneously, mortally injured, or sustain recoverable injury and TTS, depends on fish size and location in the water column (i.e. depth), and geometry of exposure.

All ESA-listed fishes that may be present in the action area are capable of detecting sound produced by explosions. The Navy calculated ranges to effects for fish species based upon the criteria discussed above. Fishes within these ranges would be predicted to receive the associated effect. Ranges may vary greatly depending on factors such as the cluster size of the explosives, location, depth, and season of the activity. According to the Navy's calculations, range to effects for any fishes without a swim bladder are presented in Table 120. These ranges would include all ESA-listed elasmobranch species that may be present in the action area such as giant manta ray, oceanic whitetip sharks, scalloped hammerhead sharks, and smalltooth sawfish.

Table 120. Range to effect for fishes without a swim bladder from explosives (Navy 2017a).

Bin	Cluster Size	Range to Effect (meters)		
		Onset of Mortality	Onset of Injury	
		SPL_{peak}	SEL_{cum}	SPL_{peak}
E1 (0.25 lb. NEW)	1	49 (40–80)	< 1 (0–2)	< 246 (100–1,025)
	100	49 (40–80)	< 17 (16–30)	< 246 (100–1,025)
E2 (0.5 lb. NEW)	1	57 (50–70)	< 3 (2–4)	< 247 (110–410)
E3 (2.5 lb. NEW)	1	105 (70–220)	< 4 (4–5)	< 543 (150–1,775)
	50	105 (70–220)	< 30 (25–40)	< 543 (150–1,775)
E4 (5 lb. NEW)	1	151 (140–370)	< 11 (6–30)	< 1,027 (625–2,025)
E5 (10 lb. NEW)	1	163 (90–330)	< 8 (7–15)	< 688 (210–2,025)
	25	163 (90–330)	< 34 (25–85)	< 688 (210–2,025)
E6 (20 lb. NEW)	1	218 (120–1,275)	< 10 (9–18)	< 950 (370–3,025)
E7 (60 lb. NEW)	1	465 (380–525)	< 26 (25–30)	< 3,643 (3,025–4,525)
E8 (100 lb. NEW)	1	419 (160–1,275)	< 21 (15–30)	< 2,224 (525–7,025)
E9 (250 lb. NEW)	1	462 (280–550)	< 24 (20–35)	< 1,749 (775–5,025)
E10 (500 lb. NEW)	1	511 (240–925)	< 32 (25–55)	< 2,307 (725–11,525)
E11 (650 lb. NEW)	1	1,075 (625–2,775)	< 74 (65–120)	< 5,693 (2,275–15,525)
E12 (1,000 lb. NEW)	1	701 (360–1,025)	< 39 (30–70)	< 2,758 (1,025–17,275)
E16 (14,500 lb. NEW)	1	5,039 (1,775–8,025)	< 322 (320–330)	< 14,997 (9,025–31,525)
E17 (58,000 lb. NEW)	1	6,740 (2,775 –11,525)	< 705 (600 –1,000)	< 20,963 (11,775–46,525)

Notes: SEL_{cum} = Cumulative sound exposure level, SPL_{peak} = Peak sound pressure level, TTS = Temporary Threshold Shift, lb = pounds, lb = pounds, NEW = net explosive weight, < indicates that the given effect would occur below the reported range(s). 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.

For ESA-listed fishes that possess a swim bladder that is not involved in hearing, such as Atlantic salmon, Atlantic sturgeon, and Gulf sturgeon, the range to effects are presented in Table 121.

Table 121. Range to effect for fishes with a swim bladder not involved in hearing from explosives (Navy 2017a).

Bin	Cluster Size	Range to Effect (meters)			
		Onset of Mortality	Onset of Injury		TTS
		SPL_{peak}	SEL_{cum}	SPL_{peak}	SEL_{cum}
E1 (0.25 lb. NEW)	1	49 (40–80)	8 (8–10)	< 453 (140 –1,025)	< 52 (45–85)
	100	49 (40–80)	73 (55–120)	< 453 (140–1,025)	< 471 (180–1,275)
E2 (0.5 lb. NEW)	1	57 (50–70)	13 (10–16)	< 467 (160 –1,275)	< 92 (55–170)
E3 (2.5 lb. NEW)	1	105 (70 –220)	20 (17–30)	< 962 (230–3,775)	< 129 (75–260)
	50	105 (70–220)	129 (75–260)	< 962 (230–3,775)	< 830 (240–2,525)
E4 (5 lb. NEW)	1	151 (140–370)	55 (25–180)	< 1,874 (850–5,275)	< 432 (150–1,275)
E5 (10 lb. NEW)	1	163 (90–330)	30 (25–75)	< 1,112 (330–4,025)	< 198 (100–490)
	25	163 (90–330)	139 (85–350)	< 1,112 (330–4,025)	< 755 (260–2,775)
E6 (20 lb. NEW)	1	218 (120–1,275)	43 (30–95)	< 1,569 (550–5,275)	< 339 (170–1,275)
E7 (60 lb. NEW)	1	465 (380–525)	147 (130–180)	< 5,338 (3,775–9,775)	< 1,504 (1,275–1,775)
E8 (100 lb. NEW)	1	419 (160–1,275)	99 (55–190)	< 3,951 (800 –13,025)	< 784 (240–2,525)
E9 (250 lb. NEW)	1	462 (280–550)	116 (75–230)	< 3,094 (1,025–17,275)	< 683 (340–1,275)
E10 (500 lb. NEW)	1	511 (240–925)	162 (95–350)	< 5,025 (975–30,525)	< 860 (370–7,775)
E11 (650 lb. NEW)	1	1,075 (625–2,775)	378 (290–875)	< 9,705 (2,525–25,775)	< 3,152 (1,525–8,525)
E12 (1,000 lb. NEW)	1	701 (360–1,025)	241 (120–460)	< 4,778 (1,525–40,775)	< 1,084 (525–7,525)
E16 (14,500 lb. NEW)	1	5,039 (1,775–8,025)	1,738 (1,275–2,275)	< 23,868 (16,025–51,775)	< 14,863 (11,525–21,775)
E17 (58,000 lb. NEW)	1	6,740 (2,775–11,525)	3,612 (2,775–4,525)	< 32,369 (12,775–85,275)	< 26,240 (13,775–51,775)

Notes: SEL_{cum} = Cumulative sound exposure level, SPL_{peak} = Peak sound pressure level, TTS = Temporary Threshold Shift, lb = pounds, NEW = net explosive weight, < indicates that the given effect would occur below the reported range(s).

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

9.2.3.2.2 Response Analysis – Fishes

Injury and Mortality – Fishes

As described previously, NMFS considers the potential effects from explosives exposure to pose the highest risk of injury and mortality compared to all other sound sources the Navy proposes to use. Based upon the range to effect calculations for onset of injury to fishes from the sound produced from explosions, fish located within hundreds (most of the charges) to thousands of meters (largest charges) could be injured or killed. In general, the explosives that belong to larger bins (with large net explosive weights) produce longer ranges within each effect category. For the largest charges, there are usually only one or very few of this type of explosives proposed for use during each five-year period of Navy training and testing. Some ranges will also vary depending upon the number of explosions in a single activity, depth and weight of the charge, etc. Fishes without a swim bladder, adult or fully developed fishes, and larger species are assumed to be generally be less susceptible to injury and mortality from explosions compared to small, juvenile or larval fishes (Navy 2017a). Other factors also influence the degree of sensitivity such as state of buoyancy, proximity to the blast (e.g., depth in the water, bodily alignment), and condition of the fish during the exposure event.

Hearing Impairment (TTS) – Fishes

For elasmobranch species, to date, no hearing loss has been demonstrated when exposed to other stressors such as air guns and pile driving. Rather, the risk of it occurring for these species is much lower than those fish that do possess swim bladders. Therefore, ranges for these species would likely be lower than what is calculated given the fact TTS has not been demonstrated at the thresholds, and the criteria for TTS is already based upon a very conservative value for more sensitive fish species with swim bladders. For fishes with swim bladders, the ESA-listed fish species that may be present in the action area do not have any hearing specializations, and do not have swim bladders involved in hearing. Similar to elasmobranchs, we are unaware of any research demonstrating TTS in these species from explosives. Although TTS has not been demonstrated in these species' groups, this does not mean it does not occur. Because we know it can occur from other acoustic stressors, we assume it is possible from exposure to an explosive sound stressor. If TTS does occur, it would likely co-occur with barotraumas, and therefore would be within the range of other injuries these fishes are likely to experience from blast exposures. Depending on the severity of the TTS and underlying degree of hair cell damage, a fish would be expected to recover from the impairment over a period of weeks (for the worst degree of TTS). Most TTS however, would likely be restored to normal hearing ranges within a few hours or days.

Physiological Stress and Behavioral Responses – Fishes

Physiological and behavioral responses of fishes to acoustic stressors have been described in greater detail for other acoustics stressors on fishes. Exposure to explosions could cause spikes in stress hormone levels, or alter a fish’s natural behavioral patterns. There are currently no behavioral thresholds for explosives established for fishes. Behavioral responses could be expected to occur within the range to effects for other injurious or physiological responses, and perhaps be extended beyond these ranges if a fish could detect the sound at those greater distances. Given that none of the species considered here have any specialized hearing adaptations, and the threshold for TTS is considered conservative for these hearing groups, most behavioral responses would be expected to occur within the range to effects for injury, mortality and TTS. These effects, depending on the severity and duration could lead to fitness consequences such as reduced survival, growth, or reproductive capacity. Because sound generated from a detonation is brief, long-term effects on fish behavior are unlikely. Similarly, long periods of masking are unlikely from blast exposure for fishes, although some brief masking periods could also occur if multiple detonations occurred (within a few seconds apart). If multiple exposures occurred within a short period of time, such as over the course of a day or consecutive days, fishes may also choose to avoid the area of disturbance. The Navy's training and testing activities involving explosions are generally dispersed in space and time throughout the large action area, and repeated exposure of individual fishes to sound and energy from underwater explosions over the course of a day or multiple days is not likely. Thus, most physiological stress and behavioral effects are expected to be temporary, of a short duration, and would return to normal quickly after cessation of the blast wave.

9.2.3.2.3 Risk Analysis – Fishes

In this section, we assess the likely consequences of the responses of individual fish exposed to explosive stressors, the populations those individuals represent, and the species those populations comprise. In the exposure and response analysis, we established that a range of impacts including mortality, barotrauma (non-auditory injury), hearing loss (TTS), and behavioral responses are likely to occur due to exposure of ESA-listed fishes to Navy explosives during training and testing events.

Atlantic Salmon – Gulf of Maine DPS

The Gulf of Maine DPS of Atlantic salmon could be present within the Northeast Range Complexes of the action area. Because these fish possess a swim bladder and are pelagic species, they could be exposed to sound energy produced during detonations and sustain injury or hearing impairment, or be killed instantaneously. Atlantic salmon could also experience masking, physiological stress, and behavioral reactions.

Since there are relatively few explosive activities in these areas throughout a given year and the size of explosives used for training activities in this area all belong to smaller bin sizes (the largest bin of E2), the ranges to effect are smaller compared to larger bin sizes. The largest area of impact (based upon the largest bin sizes) corresponding to peak pressure for onset of injury is expected to be less than 467 m (maximum of 1,275 m) from the detonation. The potential onset of TTS is 92 m (maximum 170 m) corresponding to the SEL_{cum} for explosives. Instantaneous mortality would not be expected beyond an average of 57 m from the source (maximum of 70 m), although fish could receive other injuries that may result in death later in time. For testing activities involving explosions in this area, larger explosives could be used (in, or below, E3, with occasional detonations of bins E8 and E11). Based upon the range to effects from bin E11 (the largest bin), the range to effects for TTS would be less than 3,152 m, (maximum 8,525 m), onset of injury at less than 9,705 m (maximum 25,77 m5), and mortality at 1,075 m (maximum 2,775 m). The use of these bomb sizes would occur less frequently than the smaller ones, so probable impacts would be associated with the smaller bins.

The only lifestage of Atlantic salmon expected to be present during these activities are migrating adult spawners, which could be present during seasonal migrations in the spring and summer. Detonations could occur throughout the water column during this time, but Atlantic salmon are not expected to be distributed throughout the water column, and are more likely to be exposed at the water's surface within the upper three meters of the water column. However, migrating adults in these areas are not expected to remain in this portion of the action area for a long duration due to their seasonal movement, and an individual fish is not expected to be exposed to multiple detonations. Additionally, adult salmon presence is expected to be limited to the late spring and early summer months, so the Navy anticipates less exposure risk due to the lack of overlap in habitat and activity areas in the range complex (Navy 2017a).

Due to the large net explosive weight, ship shock trials may result in the farthest ranges to mortality, injury and hearing loss. These trials are conducted in off shore areas where Atlantic salmon would not likely occur. Therefore, effects from explosives are limited to the ranges described above.

As previously described, TTS has not been demonstrated in this hearing group from explosives exposure, and for the other reasons provided, few individuals out of the population would be expected to be exposed to injurious sound levels during the Navy's activities in this area due to the short-term, infrequent and localized nature of the activities. It should be noted that if a school of Atlantic salmon were present within the vicinity of an explosive, this could result in a larger number of individuals affected during an event. Although we are unable to quantify exactly how many Atlantic salmon would be injured or killed from explosives, we assume based on location, duration and timing of exposures, a low number of adult Atlantic salmon would be impacted and potentially killed or injured. Further away from the blast, some salmon who are not injured may also detect the blast and exhibit startle or other responses. These responses are expected to be short-term and infrequent based on the low probability of co-occurrence between Navy training and testing activities with Atlantic salmon. Most of these activities will occur beyond 3 NM from shore and not in the bays and estuaries where Atlantic salmon would be present in higher numbers during seasonal migration periods.

Atlantic Sturgeon DPSs

Within the action area, five Atlantic sturgeon DPSs may be exposed to sound and energy from explosives associated with training activities throughout the year. These include the threatened Gulf of Maine DPS and the endangered New York Bight, Chesapeake, Carolina, and South Atlantic DPSs of Atlantic sturgeon. No juvenile or larvae sturgeon are expected to be present in the action area during any of the Navy's activities that use explosives. Therefore, the only life stages NMFS anticipates will be present are adult and sub-adult Atlantic sturgeon that occur within the nearshore training and testing areas in the Northeast, Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes, in the Chesapeake Bay and the NUWC Newport Testing Range; with the potential for a few to occur in offshore areas along the continental shelf (Navy 2017a).

There are gaps in our understanding about the offshore marine distribution of Atlantic sturgeon, and much of the available data point to Atlantic sturgeon predominantly using relatively nearshore, shallow habitats. Studies focusing on Atlantic sturgeon in the New York Bight have found that Atlantic sturgeon appear to prefer waters 20 m or less (Dunton et al. 2010) with no captures occurring in waters greater than 20 m (Dunton et al. 2015). Other observations have found Atlantic sturgeon in deeper waters (up to 50 m; Stein et al. 2004a), and even as deep as 75 m (Collette and Klein-MacPhee 2002). In South Carolina, tagged Atlantic sturgeon were detected up to 24 km (13 NM) from shore in waters between 10 and 20 m deep.

There is also evidence that Atlantic sturgeon marine habitat use changes with season. Erickson et al. (2011) found that some Atlantic sturgeon occupied deeper waters in the fall and winter (October through March) than in the spring and summer. From April to June, sturgeon occupied a mean water depth (rounded up) of 13 m (4 to 38 m), and 10 m (5 to 25 m) in July through September. In fall (October through December) and winter (January through March), Atlantic sturgeon occupied deeper waters, averaging 16 m (2 to 34 m) and 24 m (7 to 38 m), respectively (Erickson et al. 2011). In 2016, fish (30 to 76 individuals) were detected at all stations in the array between 39 and 70 km from shore in the months of January and February. Eight Atlantic sturgeon were also detected on the furthest receiver (i.e., 83 km from shore) during the same time period. In addition, aggregations of Atlantic sturgeon have been detected by telemetry arrays off the coast of Virginia, with groups of 40 or more individuals found at stations 53 km (29 NM) offshore (20 to 30 m deep) in January through April (Watterson et al. 2017). Groups of six to 20 sturgeon were found as far as 83 km (45 NM) from shore (30 to 40 m deep) during that same period. In summer, there were no sturgeon detections that far from shore. The few sturgeon that were detected were closer to shore (28 km or less [15 NM], in waters less than 15 to 20 m deep). Therefore, based upon these data for Atlantic sturgeon marine distribution, it is possible that some Atlantic sturgeon could be exposed to the explosives use from the Navy's activities. Atlantic sturgeon would be more likely to be present offshore of the Chesapeake Bay during cooler months such as winter and spring. By fall, they are usually either in the Bay or spawning in the James and York rivers by September and early October. They are found again in the nearshore waters by late November and early December with peak numbers in December. They remain offshore of Virginia through the spring, then begin to migrate into shallower waters and into the estuaries around April. In the event that an Atlantic sturgeon is exposed to a detonation, it could suffer hearing loss or other lethal and non-lethal injuries, stress, as well as exhibit behavioral responses. Below we consider the potential effects to Atlantic sturgeon from explosives.

There is no available information on the hearing capabilities of Atlantic sturgeon specifically, although the hearing of two species of sturgeon have been studied. While sturgeon have swim bladders, they are not known to be used for hearing, and thus sturgeon appear to rely primarily on their ears for hearing. Popper (2005) reported that studies measuring responses of the ear of European sturgeon (*Acipenser sturio*) suggest sturgeon are likely capable of detecting sounds from below 100 Hz to about 1 kHz, indicating that sturgeon should be able to localize or determine the direction or origin of sound. Meyer and Popper (2002b) recorded auditory evoked potentials of varying frequencies and intensities for lake sturgeon (*Acipenser fulvescens*) and found that lake sturgeon can detect pure tones from 100 Hz to 2 kHz, with best hearing sensitivity from 100 to 400 Hz. They also compared these sturgeon data with comparable data for oscar (*Astronotus ocellatus*) and goldfish (*Carassius auratus*) and reported that the auditory brainstem responses for the lake sturgeon were more similar to goldfish (which is considered a hearing specialist that can hear up to 5 kHz) than to the oscar (which is a non-specialist that can only detect sound up to 400 Hz). These authors felt additional data were necessary before lake sturgeon could be considered specialized for hearing (Meyer and Popper 2002b). Lovell et al. (2005) also studied sound reception and the hearing abilities of paddlefish (*Polyodon spathula*) and lake sturgeon. They determined that paddlefish and lake sturgeon were responsive to sounds ranging in frequency from 100 to 500 Hz, with the lowest hearing thresholds from frequencies in a bandwidth of between 200 and 300 Hz and higher thresholds at 100 and 500 Hz; lake sturgeon were not sensitive to sound pressure. We assume that the hearing sensitivities reported for these other species of sturgeon are representative of the hearing sensitivities of all Atlantic sturgeon DPSs. Although sturgeon hearing is not considered particularly sensitive, they do possess a swim bladder and therefore would be expected to sustain the range of barotrauma's and physiological responses associated with fishes that possess swim bladders, such as mortality, non-lethal injury, temporary loss of hearing and physiological stress.

Within the action area, the Navy's training activities that involve underwater detonations and explosive munitions, specifically larger charge or bin sizes, most often occur more than 3 NM from shore. This reduces the likelihood that Atlantic sturgeon would be exposed (though as noted above, some Atlantic sturgeon would be expected in deeper waters during certain times of the year). Although sturgeon are most likely to occur in the Chesapeake Bay, there are relatively few explosive activities that occur throughout a given year in this area, most of which belong to smaller bin sizes (largest bin used is E2). Some sturgeon may be present in the Northeast Range Complexes, where only explosives categorized in small bins are used (largest bin used is E2). These smaller bins produce smaller ranges to effects such as mortality, injury and hearing loss compared to larger bin sizes. For bin E2, the largest area of impact corresponding to onset of injury is expected to be less than 467 m (maximum of 1,275 m) from the detonation. The potential onset of TTS range is an average of less than 92 m (maximum range of 170 m). Mortality would not be expected beyond an average of 57 m from the source (maximum of 70 m).

Though as noted above, the majority of explosives occur in deeper, offshore waters, in the nearshore areas of the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes, some larger charge sizes are used and sturgeon in these areas have a higher potential to be exposed to explosives in these range complexes. The majority of the explosives the Navy uses in these areas are in, or below, bin E6 (e.g., 20-pound net explosive weight) with occasional detonations of larger charge sizes such as bins E9, 10 and 12 (Navy 2017a). This would result in potentially larger ranges to mortality, injury, and temporary hearing loss. The largest area of impact corresponding to bin E12 could result in an average distance of less than 23,868 m (maximum distance of 51,775 m) corresponding to the peak onset of injury criteria. TTS is expected to be less than 14,863 m (maximum of 21,775 m) from the detonation. Mortality would not be expected beyond an average of 5,039 m from the source (maximum of 8,025 m).

Similar to Atlantic salmon, exposures of sturgeon are expected to be of a short duration and the use of these larger bin size charges is limited to only a few per year. As with salmonids, TTS has also not been demonstrated in this hearing group from explosive exposure. Along with potential injury, Atlantic sturgeon could experience other responses as described in the beginning of this section such as physiological stress, masking or other behavioral reactions. It is likely that the explosive detonations are detectable to ESA-listed sturgeon found within the action area, and as such, may elicit a behavioral response. Due to short duration of explosions, dispersed and infrequent use throughout the ranges, and the localized nature of these activities, Atlantic sturgeon are unlikely to be exposed multiple times within a short time and the physiological stress or behavioral reactions would be expected to be temporary, returning to normal within a short period of time following cessation of the detonations.

Within the NUWC Newport Testing Range, there are a few explosive activities that are expected to occur associated with testing throughout the year. All of the explosive charges belong to smaller bin sizes (largest bin used is E0); therefore, the probability of any impacts on sturgeon in this area would be extremely low. The highest probability of Atlantic sturgeon to be exposed to explosives is in the Virginia Capes and Jacksonville Range Complexes, followed by the Navy Cherry Point and Northeast Range Complexes, based on the amount of activities that occur in these areas. Most of the explosives used in these ranges can be categorized into small bin sizes which typically produce smaller ranges to higher order effects such as mortality, injury and hearing loss compared to larger bin sizes. Some larger charge sizes that are used in these range complexes could result in larger ranges to mortality, injury and hearing loss. If exposures did occur, Atlantic sturgeon that are not killed or injured could also experience masking, physiological stress, and behavioral reactions. Due to short duration of explosives, dispersed and infrequent use throughout the ranges, and localized nature of these activities, Atlantic sturgeon are unlikely to be exposed multiple times within a short period and any physiological or behavioral reactions would be expected to be brief (seconds to minutes).

Due to the large net explosive weight, ship shock trials may result in the farthest ranges to mortality, injury and hearing loss. However, these trials are conducted in offshore areas where Atlantic sturgeon would not likely occur.

Giant Manta Ray

Giant manta rays may be exposed to sound and energy from explosives associated with training activities throughout the action area. Giant manta rays have the highest probability of being exposed to explosives beyond 3 NM from shore within the Virginia Capes, Jacksonville, and

Navy Cherry Point Range Complexes due to the high amount of activities that occur in these areas (Navy 2017a). In other areas such as the Gulf of Mexico, Northeast, and Key West Range Complexes, they have a lower probability of exposure. Within the Virginia Capes, Jacksonville, and Navy Cherry Point Range Complexes, larger charge sizes will be used which results in potentially larger ranges to mortality and injury. The majority of the explosives used in these ranges are categorized in, or below, E6 with occasional detonations of larger charge sizes of bins E9, 10, 11, and 12. Although ship shock trials involve the largest net explosive weights, resulting in the greatest ranges to effects, they are only expected to occur a few times (i.e., no more than four; three small one large) during each five-year period of Navy activities.

Although there have been no studies examining the direct effects of exposure to specific anthropogenic sound sources in any species of elasmobranchs (Casper et al. 2012a), Giant manta rays (as with all fish species) have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005b; Popper and Schilt 2009). Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012a; Casper and Mann 2006; Casper and Mann 2009b; Ladich and Fay 2013b; Myrberg 2001; Yan et al. 2003). However, unlike most teleost fish, elasmobranchs do not have swim bladders (or any other air-filled cavity), and thus are unable to detect sound pressure, therefore particle motion is presumably the only sound stimulus that can be detected by elasmobranchs (Casper et al. 2012a).

Because Giant manta ray do not possess a swim bladder, these species are considered less susceptible to barotrauma associated with exposure to the shock wave produced during a detonation compared to salmon and sturgeon. In addition, given their assumed hearing range, elasmobranchs are anticipated to be able to detect the sound and energy produced during a detonation, if exposed, but are not considered especially susceptible to hearing loss from exposure to explosives, therefore the largest zone for range to effects from explosives exposure used during both training and testing is based upon the maximum area from bin E12, corresponding to the onset of physical injury (for fish without swim bladders) of an average distance of 2,758 m (maximum 17,275 m), with a potential mortality range of 701 m (maximum 1,025 m) from the source.

Although Giant manta rays may have a higher risk of exposures to explosives in areas occurring within the complexes 3 NM offshore, due to the dispersed, infrequent occurrence and short duration of explosives' use throughout the ranges, giant manta rays are unlikely to be exposed multiple times within a short period of time and instances of injury or mortality are not expected to occur frequently. Any physiological or behavioral reactions would be expected to be brief, returning to normal within a short period of time once explosives use cease.

Gulf Sturgeon

Gulf sturgeon may be present in the action area during the use of explosives during training activities throughout the year in the Gulf of Mexico Range Complex and particularly in the Naval Surface Warfare Center, Panama City Division Testing Range during testing activities.

Navy activities that involve underwater detonations and explosive munitions typically occur more than 3 NM offshore, reducing the likelihood that Gulf sturgeon would be present in the action area. Both adult and sub-adult Gulf sturgeon life stages could be exposed to explosives, although the probability is expected to be low because these life stages typically occur in nearshore areas, bays and estuaries, but occasionally move into slightly deeper, offshore areas. Juvenile and larval sturgeon are not expected to be present as they primarily occur in estuarine and riverine systems.

Because the Panama City Division Testing Range is located partially within the surf zone, the Navy will avoid line charge testing here (except within the designated location on Santa Rosa Island) between October and March. This restriction will help avoid migration periods of Gulf sturgeon from winter feeding grounds in the Gulf of Mexico to the spring and summer natal rivers of the Yellow, Choctawhatchee River, and Apalachicola River. The majority of the explosives used in this area during training activities can be categorized in, or below, E6; most of the explosives used in testing these ranges will be within the small bin sizes of E4 with rare detonations of larger charge sizes (e.g., bin E10 or E14). Due to the large net explosive weight ship shock trials are conducted in off shore areas where Gulf sturgeon would not likely occur.

As with other sturgeon species (See above discussion on hearing in Atlantic sturgeon section), we assume that Gulf sturgeon can detect the sound produced during an explosion, but their hearing is not considered particularly sensitive. They do possess a swim bladder and therefore would be expected to sustain the range of barotrauma and physiological responses associated with fishes that possess swim bladders, such as mortality, non-lethal injury, temporary loss of hearing, and physiological stress. Activities that are conducted in the Gulf of Mexico Range Complex that could result in mortality, injury, or hearing loss are based on size of the detonations used in the range complex. The range to effects for onset of injury during training activities extends for an average distance of less than 5,025 m (maximum 30,525 m) with a mortality range of 511 meters (maximum of 925 m), if TTS were to occur, the range to this effect would be less than 860 m (maximum of 7,775 m) from the source. The Navy expects for the exposure duration to be short, infrequent and localized within these areas. Therefore, any non-injurious responses such as behavioral reactions would be temporary and brief, with normal behaviors and stress levels resuming once the detonations cease.

Oceanic Whitetip Shark

Within the action area, oceanic whitetip sharks may be found in deeper offshore waters and have the highest likelihood of being exposed to explosives beyond the 3 NM offshore range within the Virginia Capes, Jacksonville, Navy Cherry Point, and Gulf of Mexico Range Complexes, with a lower probability of exposure in the Northeast and Key West Range Complexes due the number of activities that involve the use of explosives in each of these regions (Navy 2017a). These species spend much of their time at the water surface, which could potentially increase their risk of exposure from surface detonations that may occur during Navy activities in the area.

The majority of the explosives used in these ranges during training activities can be categorized in bins E6 or below with occasional detonations of larger charge sizes (e.g., bins E9, 10 and 12).

During testing activities, the explosives used in these ranges can be categorized in, or below, E6 with occasional detonations of larger charge sizes (e.g., bins E9, 10 and 11), all within the same bin sizes as training activities. Currently there are no data regarding TTS in sharks and they do not possess a swim bladder. Thus, they may be less susceptible to barotrauma associated with exposure to the shock wave produced during a detonation compared to salmon and sturgeon. Nonetheless, we assume that they could be injured or killed, but the risk of this occurring is expected to be lower than fish with swim bladders. Therefore, the largest zone for range to effects from explosives exposure is based upon the maximum area from bin E12, corresponding to the onset of physical injury (for fish without swim bladders) of an average distance of less than 2,758 m (maximum 17,275 m), with a potential mortality range of 701 m (maximum 1,025 m) from the source.

Ship shock trails occur offshore and use large net explosive weight, thus could result in the largest area of impact for oceanic whitetip sharks. These activities are limited in the number of events that would occur, to no more than four times in a five-year period. These species have a higher risk of exposures to explosives in areas occurring within the complexes occurring 3 NM offshore, and at the water surface. Due to the dispersed, infrequent occurrence and short duration of explosives use throughout the ranges, and the rarity of oceanic whitetip shark presence, they are unlikely to be exposed multiple times within a short period of time. If oceanic whitetip sharks are exposed, they could suffer mortality, injury, and hearing loss. Given their assumed hearing range, these species are anticipated to be able to detect the sound and energy produced during a detonation, if exposed. Any physiological stress or behavioral reactions would be expected to be brief, returning to normal within a short period of time once cessation of explosive detonations occurs.

Scalloped Hammerhead Shark – Central and Southwest Atlantic DPS

Scalloped hammerhead sharks may occur in the southern portions of the Jacksonville Range Complex, but this is not the portion of the range complex where explosive activities occur (i.e., outside of the Jacksonville OPAREA). Due to the low number of activities that occur in the KWRC, the probability that scalloped hammerhead sharks would be exposed to explosives is low. Although highly unlikely, exposures of scalloped hammerhead sharks could lead to mortality or injury if they are close enough to a detonation. As with other elasmobranch species, scalloped hammerhead sharks are not considered particularly susceptible to hearing loss from exposure to explosives. Exposures would be more likely to lead to masking, physiological stress, and behavioral reactions, although these impacts would be expected to be short-term, and infrequent based on the low probability of co-occurrence between training activities and this species' presence. Additionally, due to the short-term, infrequent and localized nature of these activities, scalloped hammerhead sharks are unlikely to be exposed multiple times within a short period, and therefore would not sustain cumulative damage from multiple exposures.

Ship shock trials in the Gulf of Mexico will occur in offshore areas where scalloped hammerhead sharks may occur. However, these activities would be conducted no more than four times in a five year period, which would reduce the number of potential exposures for this species. If a scalloped hammerhead shark is within the range of a detonation during a ship shock trial, it could be injured or killed, or have physiological and behavioral reactions. Based on this, we assume scalloped hammerhead sharks located within a distance of 14,997 m (maximum of 31,525 m) could be injured or killed, with mortality more likely within a range of 5,039 m (maximum of 8,025 m). Further away from these zones, scalloped hammerhead sharks could experience physiological stress or exhibit behavioral responses. Any non-injurious responses are expected to be brief and insignificant, returning to normal within a short period of time once cessation of explosive detonations occurs.

Smalltooth sawfish

Smalltooth sawfish may be exposed to explosives throughout the year if they are present within the Key West and Gulf of Mexico Range Complexes, SFOMF, and the Naval Surface Warfare Center, Panama City Division Testing Range. There is also a small probability that smalltooth sawfish could occur in southern portions of the Jacksonville Range Complex, but this occurrence is considered unlikely because smalltooth sawfish primarily occur in southern Florida. Because adult sawfish typically spend most of their time in shallow habitats rather than the deeper waters offshore beyond 3 NM, they are unlikely to be exposed to most of the Navy's activities using explosives as the vast majority of these exercises takes place at least 3 NM from shore. Most of the explosives used in these ranges can be categorized into small bin sizes (e.g., E5), with a few from the larger charge sizes (e.g., E14). Based on the average and maximum distances for bin E5, if any smalltooth sawfish are present they could be killed or injured if located within a range to the distance for onset of injury, of less than 1,112 m (maximum 4,025 m) with a mortality range of 163 m (maximum of 330 m), from the source for the single cluster, and less than 1,112 m (maximum 4,025 m), with a mortality zone of 163 m (maximum 330 m) for the larger, 25-cluster size.

Although the probability of exposure is low for this species, if exposures did occur, smalltooth sawfish could also experience lethal and non-lethal injuries as well as masking, physiological stress, and behavioral reactions. However, due to short duration of explosives, and dispersed use throughout the ranges where smalltooth sawfish may be present, they are unlikely to be exposed multiple times within a short period of time, therefore they would be expected to recover from non-lethal injuries and any physiological or behavioral reactions would be expected to be brief (seconds to minutes) and return to normal once a detonation cease.

Ship shock trials are not expected to occur where smalltooth sawfish would occur, because these activities occur far off the coastline.

9.2.3.3 Vessel Strikes – Fishes

Navy activities that may result in adverse effects on Atlantic DPSs of sturgeon and Gulf sturgeon involve vessels transiting through the areas fish may occupy within the action area. A discussion of the relative magnitude and location of these activities is presented in the Navy's BA (Physical Disturbance and Strike Stressors), and Table B-1 in Appendix B of the AFTT DEIS/OEIS (Navy 2017c), and Section 6.4.1 of this biological opinion.

Because pelagic and most demersal fishes are anticipated to be able to avoid Navy vessels or be located out of range, the highest risk posed by vessel strikes within the action area on ESA-listed fish species is on the five DPSs of Atlantic sturgeon including the threatened Gulf of Maine, endangered New York Bight, Chesapeake, Carolina, and South Atlantic DPSs, as well as Gulf sturgeon. Of these, Atlantic sturgeon (Chesapeake Bay and Carolina DPSs), and Gulf sturgeon have the highest potential to encounter vessels used during Navy training and testing activities and possibly be hit. These species groups are not likely to congregate in any of the Navy's training or testing areas, but may be randomly distributed throughout the action areas in relatively low densities, except for some of the nearshore areas described below.

The Navy's training and testing activities involve vessel traffic within the marine environment, and the transit of any vessel in waters inhabited by ESA-listed species carries the risk of a vessel strike. The Navy conducts many training and testing activities in inshore waters, many of which involve high speed, smaller military vessels operate at speeds between greater than 10 knots, but on average 25 and 39 knots (29 - 45 miles per hour) during training operations. High speed vessel maneuvers further increase the potential risk of vessel strikes by reducing the available reaction time of both the fish and vessel operator to an impending strike. The Navy activities do not differ seasonally and could be widely dispersed throughout the action area, but would be more concentrated near naval ports, naval piers, and range areas (Navy 2017a). Activities would especially be concentrated in the Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes, as well as in inshore waters.

Many of the Navy inshore training activities involve a large degree of high speed vessel movement which primarily occur in Narragansett Bay in Rhode Island; the lower Chesapeake Bay, York River, and James River (including tributaries) in Virginia; Cooper River in South Carolina; and St. Johns River, Mayport Basin, Port Canaveral, and St. Andrew Bay in Florida (Navy 2017a). There is considerable information documenting vessel strike of sturgeon by recreational watercraft in many of these river systems. However, the actual vessel usage by the Navy depends on military training and testing requirements, deployment schedules, annual budgets, and other unpredictable factors (Navy 2017a). Within the established complexes in the action area, the Navy's use of these areas has not appreciably changed in the last decade and is not expected to change in the foreseeable future. Therefore, the usage and concentration of vessel movement is expected to be consistent within the range of variability observed over the last decade.

9.2.3.3.1 Potential Effect of Vessel Strikes

Vessel strikes are known to adversely affect ESA-listed fishes (e.g., Brown and Murphy 2010). The probability of a vessel collision depends on the number, size, and speed of vessels, as well as the distribution, abundance, and behavior of the species (Conn and Silber 2013a; Hazel et al. 2007; Jensen and Silber 2004a; Laist et al. 2001; Vanderlaan and Taggart 2007). If an animal is struck by a vessel, it may be killed, or suffer injuries. Although most fishes are able to detect and avoid vessels those species that typically are distributed near the water's surface or higher in the water column and are large-bodied fish, may be at greater risk of being struck by a vessel. Large, slow-moving fishes such as whale and basking sharks (Navy 2017a; Ramirez-Macias et al. 2012; Rowat et al. 2007; Speed et al. 2008; Stevens 2007), manta rays (e.g., Braun et al. 2015; Couturier et al. 2012; Deakos et al. 2011), and sturgeon (e.g., Brown and Murphy 2010; Couturier et al. 2012), cannot avoid all collisions, with some collisions result in mortality.

In most cases, fishes are able to detect vessels and avoid them. However, fish behavior in the vicinity of a vessel can be variable, depending on several factors such as life stage, life history, and environmental parameters. The potential responses of fishes to a physical strike may include physical injury or mortality, physiological stress, or behavioral changes such as avoidance, altered swimming speed and swimming orientation (direction). Fish are able to use a combination of sensory cues to detect approaching vessels, such as sight, hearing, and their lateral line (for nearby changes in water motion). Many fishes respond by darting quickly away from the stimulus, while others may respond by freezing in place and adopting cryptic coloration, etc. A study on fish behavioral responses to vessels showed that most adults exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jorgensen et al. 2004), reducing the potential for vessel strikes. Misund (1997) found that fish ahead of a ship showed avoidance reactions at ranges of 160–490 ft (50–350 m). When the vessel passed over them, some fish responded with sudden escape responses that movement away from the vessel laterally or through downward compression of the school. In an early study conducted by Chapman and Hawkins (1973), the authors observed avoidance responses of herring from the low-frequency sounds of large vessels or accelerating small vessels. Avoidance responses quickly ended within ten seconds after the vessel departed. Conversely, Rostad et al. (2006) observed that some fish are attracted to different types of vessels (e.g., research vessels, commercial vessels) of varying sizes, noise levels, and habitat locations. Regardless of the response, there is the potential for some type of stress or energetic cost as an individual fish must stop its current activity and divert its physiological and cognitive attention to responding to the vessel (Helfman et al. 2009). Although the energetic costs depend on the specific situation, 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 magnitude of the energetic cost and duration would determine how much of a fitness consequence this would be for an individual (if any). Additionally, smaller, or juvenile fishes could be displaced by vessels and not struck in the same manner as adults of larger species.

9.2.3.3.2 Exposure, Response, and Risk Analysis

Atlantic Sturgeon

When sturgeon are located offshore in oceanic portions of the action area, they are unlikely to encounter Navy vessels because the fish are likely located at depths greater than 15 m, and below the draft depth of even the largest Navy vessels (Nimitz-class aircraft carriers have a draft of 41 ft [12.5 m]). Plus, considering best available information, including recent research (e.g., Watterson et al. 2017), it would be an uncommon occurrence for an Atlantic sturgeon to encounter Navy vessels in deeper offshore waters of the action area due to the large area over which Navy vessels could potentially conduct training and testing activities and the relatively low number of sturgeon. Therefore, vessel strikes in the nearshore and offshore waters of the action are possible, but likely for only a very small percentage of individual Atlantic sturgeon. The frequency of large vessel traffic in nearshore environments and in and around some ports presents a higher risk of Atlantic sturgeon being struck over time. The data by Watterson et al. (2017) indicate sturgeon spend a high percentage of time in bays and estuaries less than 15 m deep, which would increase their risk of vessel strikes during period of co-occurrence with Navy activities. Coupled with known research indicating an increased sturgeon presence during certain times of year, narrow widths and channel depths of navigation channels, and somewhat confined areas in bays and estuaries, results in an increased potential for sturgeon and vessel (and in-water device encounters), especially in the Chesapeake Bay region.

For this analysis, we assume that all dead sturgeon reported with evidence of a vessel strike were killed by the vessel.[36] Furthermore, while we recognize that there are unobserved sturgeon vessel strike mortalities at sea, we assume that reported data are not biased in their relative representation of vessel strikes, thereby assuming that a sturgeon struck and killed by vessels at sea are just as likely to wash ashore and be found by salvage and reporting efforts as those that have died at sea of other causes. With these assumptions, we rely on the information regarding the relative percentage of dead sturgeon reported that have evidence of vessel injuries in estimating the percentage of sturgeon mortality due to vessel strikes along the Atlantic coast in the action area.

The five DPSs of Atlantic sturgeon frequent the coastal shelf waters along the Atlantic Ocean and return to their natal rivers to spawn. Therefore, they have the potential to encounter Navy vessels over a large portion of the action area, spanning waters from the continental shelf of Canada to the northeastern coast of Florida, as well as in many of the inshore areas where the Navy conducts training and testing activities; especially the lower Chesapeake Bay and its tributaries. Data from the Navy's acoustic telemetry array in the Chesapeake Bay has shown that Atlantic sturgeon from all five DPSs have been observed in the Chesapeake Bay (Hager 2016), with spawning populations present in the James (Balazik 2012; Balazik et al. 2012a) and York Rivers (Hager et al. 2014b). The following section discusses the presence and potential for vessel strikes on Atlantic sturgeon within the overlapping areas of Navy activity spanning from the northern portions to the southern portions of Atlantic sturgeon distributions along coastal and offshore waters of the Atlantic Ocean.

The Navy conducts a number of training exercises in the Narragansett Bay, Rhode Island each year. These activities involve approximately 16,500 hours of high speed vessel movements. However, there is very little vessel strike data for this area. While it may be that sturgeon are

[36] It should be noted some sturgeon that show evidence of vessel strikes may have already been dead and floating at surface at the time of being hit by a vessel. However, we have no way of knowing this, thus the vessel strike analysis presented here is highly conservative.

located in deeper waters and not subject to strikes, there is very little information on the occurrence of Atlantic sturgeon in Narragansett Bay or the depth range they inhabit while there. Should sturgeon occur in the bay and be shallow enough in the water column, there is a chance that a strike could result from Navy training activities. NMFS also receives information regarding sturgeon carcasses from permittees under a salvage and research program (L. Lankshear, NMFS, personal communication to J. Meyer, NMFS, 2018). The data spans rivers along the Atlantic coast from Maine to South Carolina, but there have not been any documented Navy vessel strikes reported. This does not mean they do not occur but that a lack of monitoring and reporting effort or a lack of knowledge by the general public in the area to know to report a stranding should they witness one could be the reason for a lack of reports rather than an absence of vessel strikes. From 2007-2018, approximately 34 percent of the dead sturgeon collected along the Atlantic coast are attributed to vessel strikes.

In New York's Hudson River, sturgeon mortalities have seemingly increased from 2009 to 2014. From the period 2009 through 2011, there were only six sturgeon mortalities reported. But, between 2012 through 2014, there were 76 known Atlantic sturgeon fatalities attributed to boat strikes around the Tappan Zee Bridge (Foderaro 2015). In addition, over two dozen more were reported during the first six months of 2015. This reflects a significant increase, which may be attributed to increased boat traffic in the area associated with the expansion of the Tappan Zee Bridge, which began in 2012, or it may be a result of increased monitoring efforts. It should also be noted that NMFS does not have any baseline data prior to monitoring and reporting efforts commencing to compare reports to in order to determine what the increased number is based upon. Regardless of the reason, these data demonstrate the vulnerability of Atlantic sturgeon to vessel strikes within the Hudson River system. From the period of 2009-2015 there were 106 sturgeon mortalities associated with vessel strikes, meaning, on average, 15 sturgeon are killed annually by vessels in the Hudson River area.

In the Delaware Bay and River, Brown and Murphy (2010), reported 28 deaths of sturgeon, with 50 percent attributed to vessel strikes between 2005 and 2008 (although the size and type of the vessels was unknown). They also indicated Atlantic sturgeon are particularly susceptible to vessel strikes in estuarine and riverine environments where the waters are shallower and more restricted, making sturgeon particularly at risk of large vessel with deep drafts. It is worth noting that the study included an unknown number of additional sturgeon mortalities that were likely struck by vessels, but not included in the total attributed to vessel strikes because the bodies were too decomposed to accurately determine the cause of death. The authors determined, based on an egg-per-recruit analysis of the Delaware River population, an annual mortality rate of 2.5 percent of the females could have adverse impacts on the population (Brown and Murphy 2010). Based upon the four years of data available, we estimate up to four sturgeon are killed annually in the Delaware Bay and River from vessel strikes.

In the Chesapeake Bay rivers, from 2007 to 2010, researchers documented 31 carcasses of adult Atlantic sturgeon in the tidal freshwater portion of the James River, Virginia. Twenty-six of the carcasses had gashes from vessel propellers, and the remaining five carcasses were too decomposed to allow determination of the cause of death (Balazik et al. 2012a). The researchers could not fully attribute all of these mortalities to specific types of vessels, but it is likely they resulted from larger vessels in narrow shipping lanes, similar to what has been observed for the Delaware River. The authors estimate that current monitoring in the James River documents less than one-third of vessel strike mortalities. The same researchers also investigated the upstream areas of the James River, for Atlantic sturgeon vessel strike mortalities occurrence and location (Balazik et al. 2012b). The study tracked three sturgeon implanted with acoustic transmitters, and concluded that, when moving, the tracked individuals occurred in water depths overlapping with the draft of ocean cargo vessels in about 7 m, but were rarely in depths overlapping the draft of tugboats and small recreational craft in 1-2 m. This was a sample size of only three fish, which may not be enough to support the conclusion; however, the three fish were detected in the navigation channel of the river 69 percent of the time. This supports the Atlantic Sturgeon Status Review Team's assertion that rivers with narrow channels and large-vessel traffic have high incidences of vessel strikes on adult Atlantic sturgeon (ASSRT 2007). In 2016, Balazik also reported that ship strikes in Virginia are not just limited to confined river systems (Balazik 2016) (Figure 60 below). These data indicate 91 sturgeon were hit by vessels between 2007 and 2016. Data from 2015 and 2016 indicate ship strikes of Atlantic sturgeon occur with some frequency within the lower Chesapeake Bay and even along the Atlantic coast. It should be noted the location of the reported fish does not necessarily reflect where the fish was struck by a vessel, only where it was observed washed ashore or floating in the water. It is also hard to determine with a high degree of certainty whether or not the vessel strike was the cause of death, meaning it is possible that a fish that was dead already, and subsequently hit by a vessel because it was floating in the water column. Research is currently underway trying to track and determine where a fish may drift after being killed. This would also assist with estimates correlating vessel types and sturgeon strikes with Navy or other commercial and non-military vessel occurrence.

In 2015, efforts to document Atlantic sturgeon mortalities in the lower James River and the Chesapeake Bay were initiated through the combined effort of the Virginia Commonwealth University, the Virginia Aquarium, and the Navy (Navy 2017a). Prior to 2015, most sturgeon mortalities were rarely documented, and those that were reported were not part of a directed study on vessel strikes, but rather reported through existing stranding networks such as local sea turtle or marine mammal stranding networks.

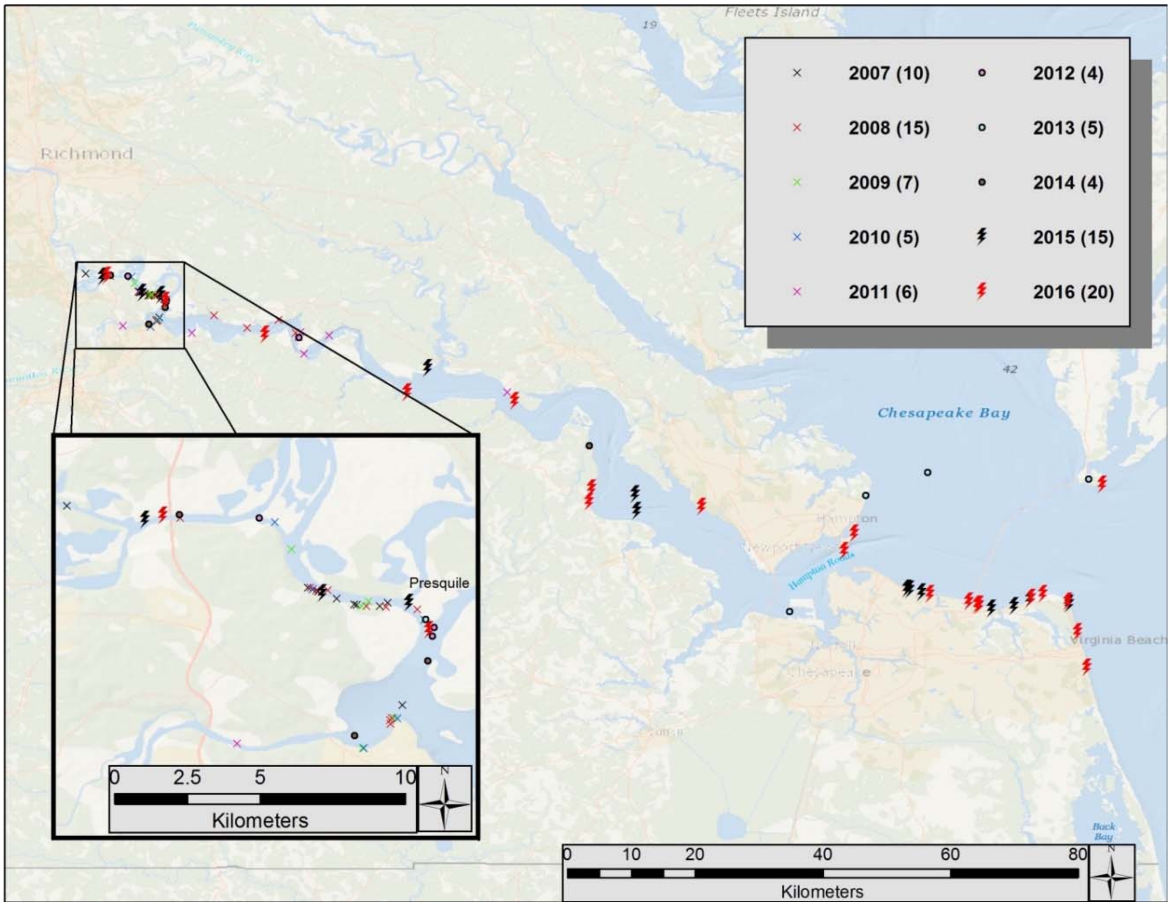

Figure 60. Documented ship strikes of Atlantic sturgeon between 2007 and 2016 (Balazik 2016) taken from the Navy 2017 Biological Assessment.

The Navy conducts extensive training exercises in lower Chesapeake Bay and the lower portions of both the James and the York Rivers, and a large proportion of these exercises involve high speed vessel movements within each of the three areas. Given the importance of the Chesapeake Bay and its tributaries to Atlantic sturgeon, the shallower depths at which sturgeon potentially occur near these areas (within the bay and rivers), and the amount of training activities involving high speed vessel movements, it is possible that a strike of Atlantic sturgeon could occur during Navy activities. For these reasons, the Navy conducted research efforts investigating the potential overlap of their activities and sturgeon presence to better understand vessel strike potential on sturgeon in these areas. They implanted 38 Atlantic sturgeon in the York River Watershed with acoustic transmitters that track the fish and also monitor the depth the fish occupy. The fish were detected via a series of acoustic telemetry receivers as they moved out of the river system and into the Atlantic Ocean. The researchers used the recorded location and depth data to calculate what percentages of the fish were present and at what depth within the given area (Watterson et al. 2017; Figure 61 and Figure 62). Based on the results, Atlantic sturgeon in the Mid-Atlantic region (10 to 50 miles offshore) and the nearshore Atlantic (1 to 10 miles outside the mouth of the Chesapeake Bay) were most frequently detected (i.e., 95 to 98 percent of the time) in deeper waters, greater than 15 m in depth.

Once these fish moved into estuarine and riverine environments, they occurred closer to the surface. In the Chesapeake Bay, as many as 53 percent of detections occurred in water shallower than 15 m, and nine percent occurred in waters less than 10 m in depth. In riverine systems, such as the York River, a much larger percentage of the time is spent at shallower depths; 65 percent of the detections of sturgeon occurred in waters less than 10 m in depth and as much as 30 percent occurred in depths less than 5 m (Navy 2017a).

The Navy estimates approximately 34,500 hours of high speed vessel movements occur annually in theses rivers of the lower Chesapeake Bay, with approximately 15,500 and 6,500 hours annually occur in the James and York rivers, respectively. However, nearly all of the high speed vessel movements are conducted by small support craft with drafts less than 10 ft (3 m) and only two percent of the detections of sturgeon within the lower Chesapeake Bay and none at the mouth of the James River occurred in waters less than 5 m of the surface, indicating strikes on sturgeon by small vessels is less likely to occur since sturgeon are likely to be located deeper, and beyond the draft of the smaller vessels. In contrast, over 30% of detections within the York River (and presumably in the upper James River) occurred at depths of less than 5 m, increasing the potential for sturgeon and vessel interaction in those areas by small vessels. In these areas, the Chesapeake Bay and Carolina DPSs are the most susceptible to vessel strike than other DPSs in the action area due to their abundance and distribution within this portion of the action area.

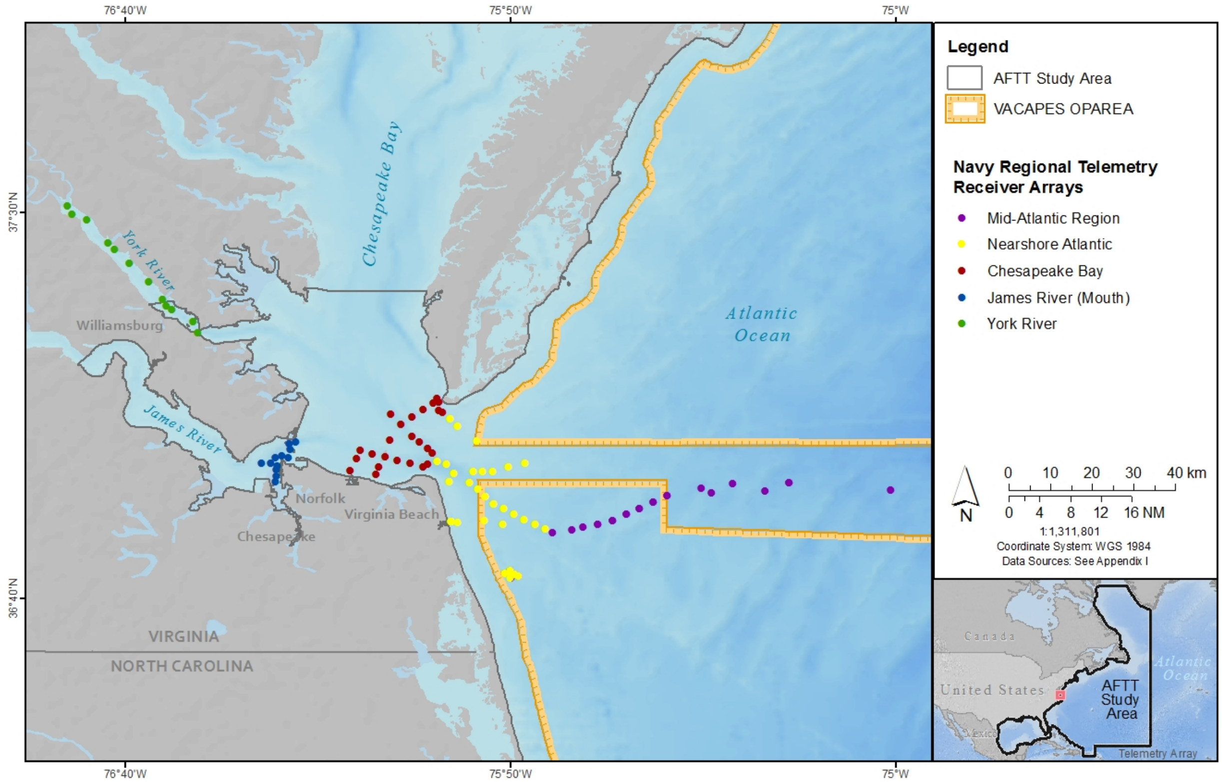

Figure 61. Navy regional telemetry arrays in the lower Chesapeake Bay and Mid-Atlantic Region.

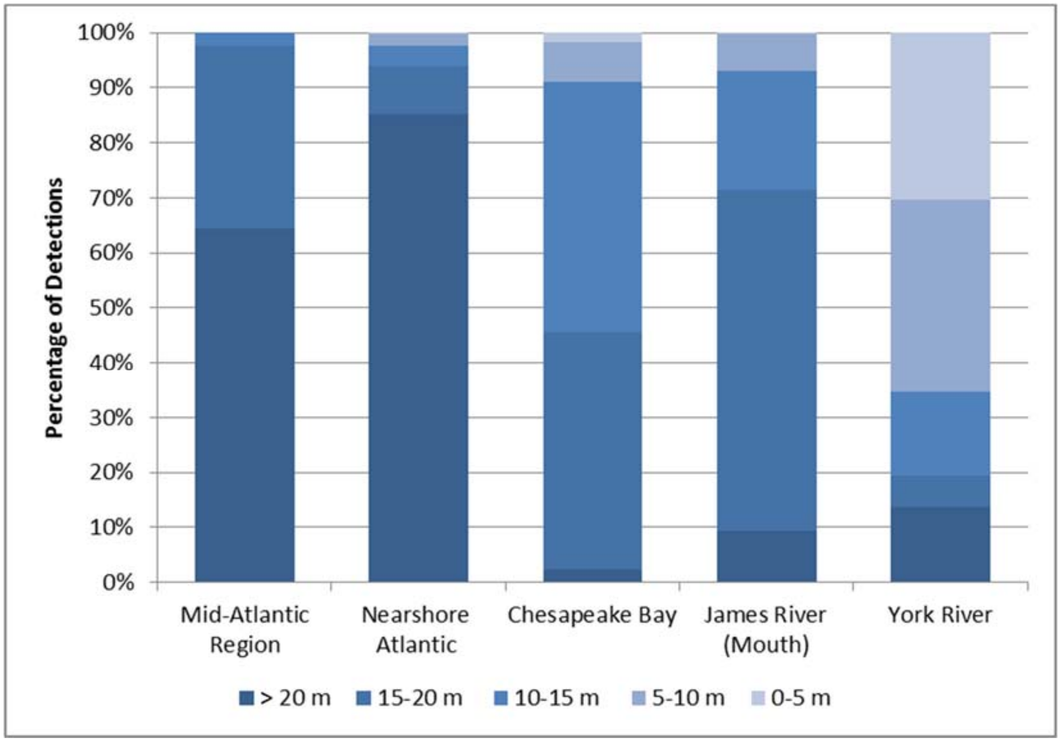

Figure 62. The percentage of detections of Atlantic sturgeon implanted with acoustic transmitters that occurred in given depth ranges within different environments (Watterson et al., 2017).

The annual number of Navy vessels in the action area varies at any given time. Activities utilizing vessels range from use of one to two vessels up to several operating at various time frames and locations. In general, the use of vessels can be grouped into two categories based upon whether the vessels are operating offshore, or inshore waters. The use of vessels in offshore areas could last from a few hours to a few weeks and operate at speeds of 10-15 knots (for large vessels) and 0-50 knots for small vessels. These vessels would be widely dispersed in the offshore waters, but more concentrated in portions of the action areas with close proximity to ports, naval installations, range complexes, and testing ranges (Navy 2017a). In contrast, activities that occur in inshore waters can last from a few hours to up to 12 hours of daily movement per vessel and can involve faster speeds (> 10 knots), potentially increasing vessel strike risk for sturgeon. However, the vessels operating within the inshore waters are generally smaller than those in the offshore waters and are considered small craft (< 50 ft).

NMFS and the Navy do not currently have vessel strike information for Atlantic sturgeon in the Cooper River, South Carolina. The Navy conducts training exercises in the Cooper River that involve up to 12,650 hours of high speed vessel movements per year. While information is not available regarding the depths at which sturgeon occur in the Cooper River, NMFS assumes it is similar to the York River. Therefore, there may be potential for vessel strikes of Atlantic sturgeon there as well.

For the St. Johns River in Florida, the Navy also funded research for over a two-year period in cooperation with the University of Georgia. The researchers established a telemetry receiver array in the river (Fox et al. 2016) and collected telemetry data from sturgeon captured and tagged. These efforts yielded only a single fish capture, which was tagged. Based on genetic analysis, this fish was not a native to the St. Johns River, but originally from the Altamaha River in Georgia. Eight other Atlantic sturgeon were also only briefly detected in the array during the course of the study during the winter and early spring months (Fox et al. 2016). Based on these survey results, the low potential of sturgeon to be present in the St. Johns River makes vessel strikes in this area extremely unlikely.

Atlantic sturgeon may occur in the nearshore and offshore waters in the vicinity of Port Canaveral, Florida. However, there have not been any documented occurrences of Atlantic sturgeon in the inshore waters where Navy training activities involving high vessel movements occur, based on the data collected through the Navy-funded telemetry array in the inshore waters of Port Canaveral, specifically within the Trident Basin where most Navy training activities in the area are conducted. Therefore, it is anticipated that vessel movements as part of Navy training activities in the vicinity of Port Canaveral, Florida will not result in impacts to Atlantic sturgeon.

Based on the reported data (from published research and supplemental salvage data) for the years spanning 2007-2018[37], we conservatively estimate up to 251 sturgeon mortalities occurring from vessel strikes along (all bays and tidal river mouths) the Atlantic coast. This results in an annual average of 22 sturgeon mortalities potentially attributed to vessel strikes throughout the action area. The Navy has estimated that they comprise 0.7 percent (Mintz 2012) of all vessel traffic throughout the action area. Based on this information, we anticipate one Atlantic sturgeon vessel strike over each five-year period of Navy training and testing activities from the portions of the action area that do not include Chesapeake Bay (14 sturgeon mortalities annually[38] x 0.007 [proportion of Navy vessel traffic in the action area] x 5 years = .49 sturgeon strikes/five year period). This estimate excludes vessel strikes that could occur in the Chesapeake Bay region, as described below. Rounding up to one vessel strike over a five year period, we anticipate one individual Atlantic sturgeon (from any of the DPSs) could be struck by a Navy vessel over a five year period in areas outside of Chesapeake Bay.

Navy vessel traffic in the Chesapeake Bay region comprises from seven to nine percent of vessel traffic (Mintz 2012b). Because the Navy vessel traffic is heavier in the Chesapeake Bay region than in other portions of the action area, and sturgeon are at higher risk of being hit in these areas by vessels due to the relatively shallow water, we estimate up to one sturgeon could be struck by

[37] We added an additional 2.5 years, from salvage data to account for vessel strikes after 2015, which is the latest date reported in the research studies.
[38] The estimate of 14 sturgeon mortalities annually is based on the overall number of sturgeon mortalities occurring from vessel strikes along the Atlantic coast, minus those occurring in Chesapeake Bay.

a Navy vessel annually (91 total vessel strikes between 2007 and 2016/10 years x .09 [proportion of Navy vessel traffic in the Chesapeake] = 0.8 vessel strikes per year; total of 5 strikes for each five-year period). We anticipate sturgeon struck in the Chesapeake Bay region will either be from the Chesapeake Bay or Carolina DPS.

Therefore, based upon these calculations, up to six Atlantic sturgeon could be struck by Navy vessels over the five-year period throughout the action area. We have used the best available information and made reasonable conservative assumptions in favor of the species to address uncertainty and produce an analysis that results in an estimate of the number of interactions between sturgeon and Navy vessels that are reasonably certain to occur.

Atlantic sturgeon are not at risk of vessel (or in-water device) strikes due to Navy training and testing activities throughout the majority of the action area. This is due to low density numbers in a majority of the action area where the Navy vessel operates and lack of congregating sturgeon at waters depths where Navy vessel strike is likely. This is especially true for offshore, marine areas, where the majority of Navy activities take place. In these areas, Atlantic sturgeon typically occur well beneath the draft depth of even the largest Navy vessels. The risk increases in those areas described above where sturgeon are known to occupy shallower waters, and are located in the more confined water ways of bays, estuaries, and navigation channels (i.e., Chesapeake Bay and its tributaries).

If an individual sturgeon does not sustain lethal injury from vessel strike, there would be an energetic cost associated with the time it takes to recover from a wound, and reduced individual fitness for the duration it takes to recover. However, due to the nature of vessel strikes on sturgeon, we assume all vessel strikes will result in lethal take of Atlantic sturgeon.

Gulf Sturgeon

Gulf sturgeon occurrence overlaps with vessel use during training and testing activities throughout the continental shelf waters of the northern Gulf of Mexico, especially in the Panama City and Pensacola OPAREAs, the Naval Surface Warfare Center Panama City Testing Range, and St. Andrew Bay.

There are little data available on vessel strikes of Gulf sturgeon. However, because of the similarity of these species and the lack of data specific to Gulf sturgeon, we assume many of the same reasons Atlantic sturgeon are susceptible to vessel strike, Gulf sturgeon would also be at risk. While not nearly as susceptible as Atlantic sturgeon based on documented strandings, some Gulf sturgeon vessel strikes have been reported. There have been two reported definitive deaths of Gulf sturgeon from vessel strikes in the past three years (Panama City Fish and Wildlife Service, unpublished data). Additionally, in our 2009 Status Review of this species (NMFS 2009e), NMFS indicated vessel strikes may be an emerging threat to Gulf sturgeon. In 2004, a juvenile Gulf sturgeon was removed from the Appalachia River with a partially severed tail immediately after a barge tow had passed through the area (NMFS 2009e). This is an underestimate of actual Gulf sturgeon deaths by vessel strike because many are unreported or sink to the bottom and are not observed. Because Gulf sturgeon share similarities with Atlantic sturgeon and the recent evidence of vessel strike for Atlantic sturgeon and Gulf sturgeon, it is possible for vessels conducting Navy training and testing activities in the northern Gulf of Mexico to potentially strike a Gulf sturgeon, although instances of strike from Navy vessels are not expected to be common. We assume Navy vessels could make up to 0.7 percent of vessel traffic in the Gulf of Mexico (Mintz 2012b). Therefore, based on the annual mortalities of one (rounded up from 0.67, based on the Panama City Fish and Wildlife Service data mentioned earlier) Gulf sturgeon being struck per year in the Gulf of Mexico and the assumption that Navy vessel traffic makes up 0.7 percent of vessel traffic in this area, there is a low probability that a Gulf sturgeon would be hit by a Navy vessel (1 x.007 = 0.007) over each five year period of Navy training and testing. Because we consider that the number of reported Gulf sturgeon vessel strikes is likely underestimated in the Gulf of Mexico, there remains a low probability of a Gulf sturgeon being struck by a Navy vessel.

9.2.4 Corals and Elkhorn and Staghorn Coral Critical Habitat

This section discusses effects to ESA-listed corals and elkhorn and staghorn coral critical habitat due to the potential exposure of these resources to physical disturbance, strike, and entanglement from the expenditure of materials during training and testing activities.

As described previously (Section 6), military expended materials will be generated from training and testing activities and will include targets (surface and aerial), mine shapes, decelerators/parachutes, sonobuoys, torpedoes, concrete slugs, markers, bathythermographs, endcaps, and pistons. Some expended materials are recovered, including torpedoes, unmanned aerial systems, some targets, mine shapes, metal plates, and bottom-placed instruments. Decelerators/parachutes of varying sizes (associated with sonobuoys, illumination flares, and air-launched torpedoes) are used during training and testing activities and may be deployed from aircraft or vessels and are not recovered. The Navy also uses biodegradable polymers during activities to test the ability of these materials to hinder movement of a vessel's propellers, though this material typically breaks up within a couple of hours (Karlsson and Albertson 1998a).

Any of these items have the potential to cause damage to ESA-listed coral colonies by physical disturbance and/or entanglement. This could result in full or partial mortality of ESA-listed coral colonies depending on the severity of the abrasion and breakage or level of smothering of colonies from this debris. Colonies impacted by debris that are sexually mature may not spawn in the year damage from expended items occurs, or even in subsequent years, depending on the extent of the damage. Expended items may also decrease the functionality of elkhorn and staghorn coral critical habitat if items cover hard substrate containing the essential feature of critical habitat, rendering it inhospitable to coral recruits. The functionality may also be decreased if expended items move across areas of critical habitat, leading to sediment resuspension or damage to the structure of the habitat.

As described previously, most training and testing activities that take place in locations where ESA-listed corals occur are conducted at KWRC and the SFOMF testing range (Figure 8). Elkhorn and staghorn coral critical habitat (Florida unit) is also present in these areas, with the exception of a small area within the SFOMF and the area subject to the Naval Air Station Key

West Integrated Natural Resources Management Plan (within 50 yards of shore). The action area also includes the Flower Garden Banks in the Gulf of Mexico where most of the ESA-listed Atlantic/Caribbean coral species have been observed, and the U.S. Caribbean where all seven species of ESA-listed corals are present (Figure 8) and designated elkhorn and staghorn coral critical habitat units (Puerto Rico, St. Croix, and St. Thomas/St. John), but very limited Navy activities occur in these locations. Our discussion below focuses on materials expended during training and testing activities in these primary training and testing locations that overlap with the distribution of ESA-listed corals and critical habitat (i.e., KWRC and SFOMF). We recognize that materials expended in other portions of the action area could eventually settle in areas with ESA-listed corals (depending on current and sinking rates), but the likelihood of this occurring is significantly lower.

9.2.4.1 Exposure Analysis

Best available information does not allow us to estimate the frequency with which military expended materials settle or make physical contact with ESA-listed corals or coral critical habitat. The frequency in which this will occur is dependent on a variety of factors including where within the training or testing range complex the material was expended, buoyancy of the expended material, and current.

The ESA-listed corals considered in this opinion are most common in water depths of 30 m or less, though corals in the star complex (particularly boulder star and mountainous star) and rough cactus coral have been documented down to 90-m depths. In the U.S. Caribbean, boulder and mountainous star corals are often dominant in depths between 40 to 50 m and common in depths up to 90 m (e.g., in areas between the eastern side of the main island of Puerto Rico and the Virgin Islands, which include Culebra and Vieques Islands). During consultation, the Navy provided information to NMFS on the materials that will likely be expended in the KWRC and SFOMF and the depth at which the materials would be expended (i.e., within or outside the depth distribution of ESA-listed corals).

For non-buoyant materials that would sink quickly once expended (e.g., large caliber projectiles), impacts to ESA-listed corals or coral critical habitat would only occur if the item were expended within the depth range of these resources and over the top of the particular resource. More buoyant materials expended, including buoys, parachutes, and some pieces of surface or subsurface targets, expended outside of the depth range of ESA-listed corals could still impact these resources if current were to bring these items into areas within the depth range of ESA-listed corals. Figure 63 shows the major current systems, including the Loop and Florida currents, in the portion of the action area that overlaps with the range of ESA-listed corals. The major currents most relevant to this discussion are the Loop and Florida currents which could bring materials expended in portions of the KWRC outside the depth distribution of ESA-listed corals to more nearshore areas around the southeastern coast of Florida. However, there is no information to indicate the frequency in which expended items may settle within the action area in locations were ESA-listed corals occur versus being transported to other locations outside of the distribution and depth range of these resources.

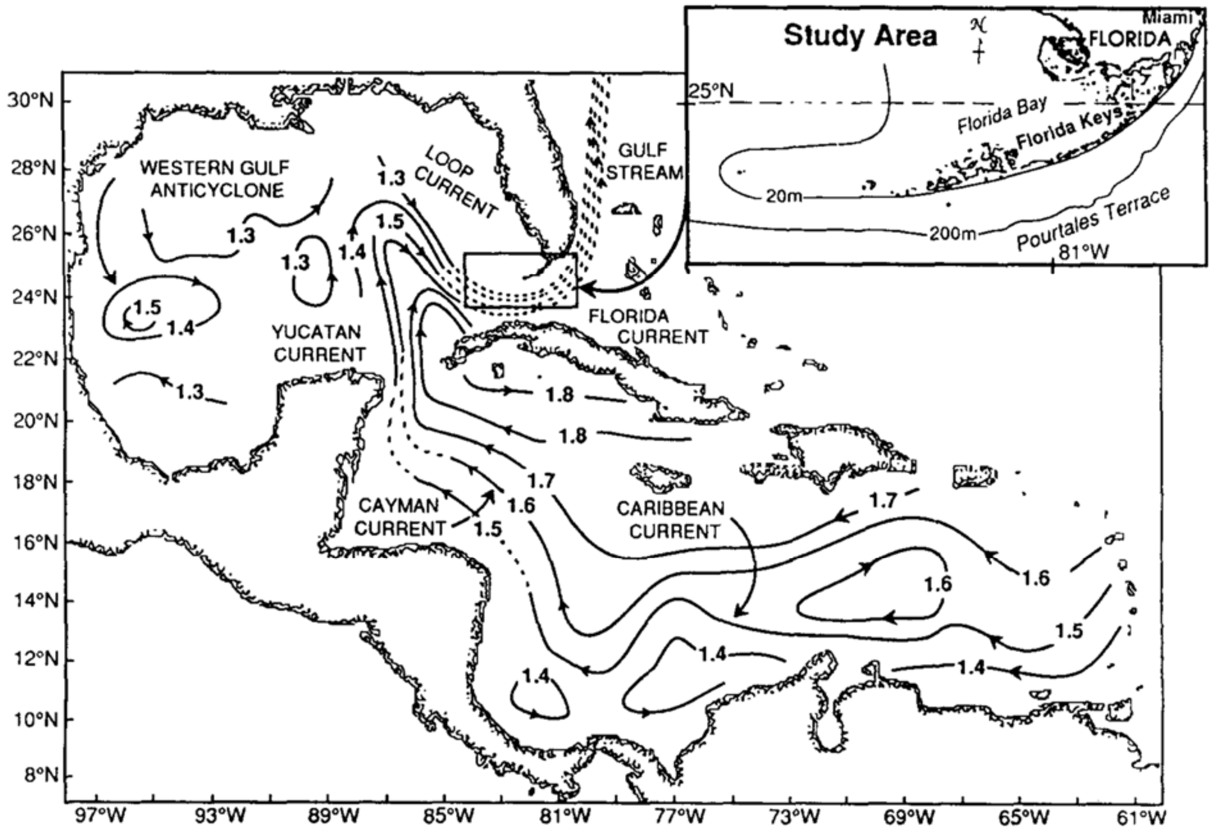

Figure 63. Major current systems in the portion of the action area within the range of ESA-listed corals. Source: Lee et al. (1992).

At SFOMF, the vast majority of material would be expended outside of the depth range of ESA-listed corals. For items that sink quickly and expended outside of the depth range of ESA-listed corals, we would not anticipate impacts to ESA-listed corals from these items. For more buoyant items, based on the current patterns in this locations (e.g., the Florida Current flowing to the Gulf Stream), we would anticipate that most of these items would be transported north out of the range of ESA-listed corals and coral critical habitat. According to supplemental information provided by the Navy during consultation, the materials that could be expended within the range of ESA-listed corals at this location are surface and subsurface targets (total of 223 targets annually).[39] Based on the size of each of these items and the number proposed annually, the total footprint of these items if/when they settle to the seafloor is 0.0035 km^2.

For KWRC, we focus our analysis on material that could be expended within the depth range of ESA-listed corals (i.e., <90 m depths) and/or within 12 NM of shore. For items expended in

[39] Note: Anchors could also be expended at this location, but potential impacts from these items were addressed in section 9.1.5.

deeper, more offshore waters (i.e., in > 90 m depth and > 12 NM from shore) in the KWRC, the likelihood that any of these materials would drift and settle on ESA-listed corals or coral critical habitat is extremely low. According to the information provided by the Navy, approximately 51 percent of material expended in the KWRC would be expended within the depth range of ESA-listed coral and/or within 12 NM of shore. Based on the size of the items that will be expended and the number proposed annually, the total footprint of items expended in these areas, if they were to settle to the seafloor, is 0.011 km^2. As discussed previously in this section, the frequency in which these items will impact ESA-listed coral or coral critical habitat is dependent on a variety of factors including where within the training or testing range complex the material was expended, buoyancy of the expended material, and current. Available information does not allow us to predict where exactly within the KWRC items will be expended, whether or not items are expended over ESA-listed corals or coral critical habitat, or where currents will take each item that is buoyant enough to not sink immediately to the seafloor.

The discussion above provided estimates of the total footprint of materials expended in the KWRC and SFOMF that have the potential to result in impacts to ESA-listed corals and coral critical habitat. However, based on best available information, incidences where an item of military origin results in impacts to ESA-listed coral or coral critical habitat would not be common. The vast majority of items expended by the Navy in south Florida would likely not impact ESA-listed corals or coral critical habitat. The area of impact to ESA-listed corals or coral critical habitat would be significantly lower than the total area of seafloor impacts provided above (i.e., total of 0.0145 km^2).

Most importantly, the vast majority of seafloor habitat in the KWRC and SFOMF that could be impacted by military expended materials is not inhabited by ESA-listed corals or designated coral critical habitat. Some of the explanation for this is provided above (e.g., a large percentage of materials will be expended outside of the depth distribution of ESA-listed corals or coral critical habitat, currents are likely to carry many expended items to locations where ESA-listed corals do not occur), but it is also important to emphasize that even within the depth distribution of ESA-listed corals, the majority of seafloor habitat does not contain these resources. Figure 64 provides information on substrate type in the KWRC. Hard bottom that could provide suitable habitat for coral recruitment represents up to 17.9 percent of the substrate within the depth range of ESA-listed corals and/or areas within 12 NM of the shoreline. Other habitat types that would not be suitable for coral recruitment (i.e., intermediate [e.g., non-stable cobble] or soft substrates) comprise the rest of available habitat. Based on this information, approximately 0.0026 km^2 of habitat that is composed of a substrate type that has the potential to support ESA-listed corals may be impacted by military expended materials.

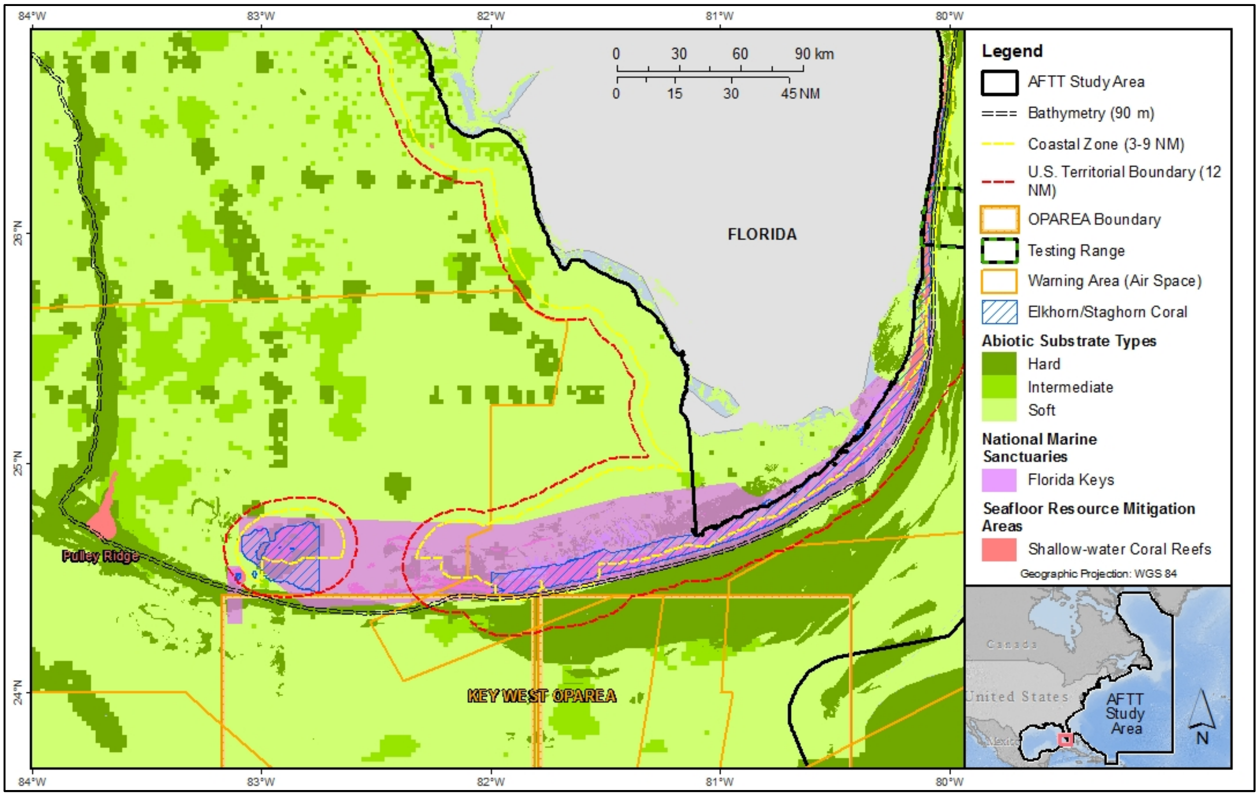

Figure 64. The distribution of known shallow-water coral reefs and hard substrate suitable for other shallow-water coral reef species (<90 meters deep) in the South Florida portion of the action area.

Additionally, even within areas that are shallow water coral reefs or contain hard bottom that may be suitable for coral recruitment, a small percentage of this area would be expected to contain live ESA-listed coral. For example, Reed et al. (2014) characterized the mesophotic benthic habitat at Pulley Ridge and the Dry Tortugas (both located within the action area). The authors found Pulley Ridge to contain 1.29 percent hard coral cover and the Tortugas to contain 0.60 percent coral cover. Also, only a subset of the hard corals in these habitats are listed under the ESA. Conservatively assuming the habitat area affected by military expended materials that is composed of substrate type that has the potential to support ESA-listed corals or coral critical habitat contains 1.29 percent hard coral cover (i.e., the average percent hard coral cover in a mapped mesophotic reef; most of the seafloor that is composed of hard substrate would have much lower percent hard coral cover), this equates to 0.00003 km^2 of impact annually to live hard coral cover. A subset of this habitat would contain ESA-listed corals, but we do not have information to estimate the percent of this habitat area that would likely contain ESA-listed corals. A similarly small amount of habitat that is likely to be impacted would be coral critical habitat. Coral critical habitat only occurs in waters to a depth of 30 m and consists of substrates including consolidated hard bottom or dead coral skeletons. Since the vast majority of materials will be expended well offshore of these areas and a majority of the substrate in areas where items are expended would be soft or intermediate bottom types, impacts to coral critical habitat would be rare.

As described above, we anticipate some instances where materials expended during military training and testing activities will likely make physical contact with and/or become entangled with ESA-listed corals and designated coral critical habitat causing harm to these resources. However, available information does not allow us to determine specifically where impacts will occur within the KWRC or SFOMF, what specific military expended material will result in impacts, or to provide a quantitative prediction of how frequently impacts will result. Further, site-specific information on the abundance and density of ESA-listed corals is not available for most locations in the action area. Even though surveys have been conducted in some locations within the action area, coral reef communities are highly variable whether humans are present or not, with species presence/absence, colony density, colony size and morphology, and other factors varying over small spatial scales (e.g., a few meters separate forereef and backreef habitats, which can have radically different coral communities). The spatial variability in coral habitat and species abundance is described in detail in the "Corals and Coral Reefs" section of the 2014 final rule to list 20 species of corals under the ESA (NMFS 2014, 79 FR 53852). While density information may be available for ESA-listed corals in some specific locations, it would not be accurate or appropriate to assume these density estimates are applicable everywhere within the range of these species or everywhere in the action area. For this reason, for the Navy's action, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take of ESA-listed coral colonies, or to monitor take-related impacts in terms of individuals of these species. Therefore, the incidental take of ESA-listed corals is expressed as a habitat area surrogate as prescribed by 50 CFR 402.14(i).

9.2.4.2 Response Analysis

Based on the information presented above, we anticipate Navy military expended materials to impact up to 0.00003 km^2 of habitat annually that may be occupied by live hard coral cover. A subset of this area of habitat is likely to contain ESA-listed coral or designated coral critical habitat. Items such as parachutes and cables, including tackle for temporary buoys and anchors, can smother and entangle ESA-listed coral colonies. This can result in full or partial mortality of ESA-listed coral colonies depending on the severity of the abrasion and breakage or level of smothering of colonies from this debris. Colonies impacted by debris that are sexually mature may not spawn in the year damage from expended items occurs, or even in subsequent years depending on the extent of the damage. Additionally, expended items suspended in the water column such as parachutes could entrap coral larvae. Entrapment in expended materials could cause immediate mortality of coral larvae or prevent larvae from locating somewhere to settle and grow while the larvae are still viable (typically, coral larvae survive for a few weeks). Expended items may also decrease the functionality of elkhorn and staghorn coral critical habitat if items cover hard substrate containing the essential feature of critical habitat, rendering it inhospitable to coral recruits. The functionality may also be decreased if expended items move across areas of critical habitat, leading to sediment resuspension or damage to the structure of the habitat.

To our knowledge, military expended material surveys in or in close proximity to SFOMF have not been conducted. A benthic survey for a proposed cable route was conducted in the SFOMF in water depths from 7 m to 106 m in 2011 (Messing 2011). The author found hard bottom in depths of 51 m or less, but part of the area had been impacted by spoil deposits associated with the original dredging of Port Everglades and the survey was confined to the proposed cable route. An additional survey by the Navy to look for ESA-listed corals within the entire SFOMF was conducted in 2011 (Gilliam and Walker 2012). The survey noted small recreational vessel anchors in many locations (i.e., snagged to underwater cables in the range), but did not document materials that could conclusively be identified as military expended materials. Elkhorn coral was the only ESA-listed coral species that was not observed during the survey conducted by (Gilliam and Walker 2012). Marine debris surveys have been conducted in the Florida Keys on reefs in close proximity to the Navy's KWRC. For example, Chiaponne et al. (2002) conducted a marine debris survey in reef areas of the Florida Keys at varying depths. The authors documented mostly derelict fishing gear, but also an assortment of other items including a glass bottle and diving weights. None of the marine debris could be identified as military expended material.

Navy (2017a) cited investigations in the Pacific Ocean (Mariana Archipelago) as an example of possible impacts from military expended materials on seafloor habitats. Water areas were not targeted at the Mariana range and bottom impacts occurred only when the target land mass was missed, or the munition bounced off the land into the water. The surveys found no overall long-term adverse impacts to corals or other invertebrates due to expended items, despite several decades of use and observations of intact bombs and fragments on the bottom (Smith and Marx, 2016). Inert 500-pound bombs were found to disturb a bottom area of 17 m^2 each, although specific damage to invertebrates was not described. Invertebrates within this footprint would likely have been killed, injured, or displaced depending on the organism. Expended inert items, once settled in place, appeared to become encrusted with marine growth and pose no substantial long-term threat to invertebrates. The condition of corals indicated a healthy environment, with no apparent change in species composition, distribution, size, or stress indicators. These results are in contrast to findings by Porter et al. (2011) indicating coral health and even the structure of the coral community on reefs in Vieques, Puerto Rico, containing expended and live ordnance, was poor. Corals were also found to have high concentrations of explosive-type compounds in their tissues up to one meter from ordnance items (Porter et al. 2011; Barton and Porter 2004 cited in Lotufo et al. 2017). A summary of data from military and former military sites around the United States, including in the U.S. Caribbean and Pacific, found that sediments were commonly contaminated in the immediate area of ordnance items and explosive-type compounds and heavy metals were sometimes found in the water column around an item, but mobile species such as fish appeared to be unaffected by contamination (Lotufo et al. 2017).

9.2.4.3 Risk Analysis

Our exposure and response analysis above indicated that, based on best available information, a total of 0.00003 km^2 of habitat that may be occupied by live hard coral cover, a subset of which would be occupied by ESA-listed corals, is likely to be vulnerable to impacts from military expended materials used during training and testing activities annually. Based on the analysis above, we also anticipate impacts to coral critical habitat, but based on best available information, such impacts would not be common. Given the large number of items expended annually, the co-occurrence of these activities with ESA-listed corals and elkhorn and staghorn coral critical habitat, impacts to ESA-listed coral colonies and elkhorn and staghorn coral critical habitat from military expended materials within this area could include breakage and abrasion, smothering, as well as a decrease in or loss of functionality of the essential feature of critical habitat. Sexual reproduction of adult coral colonies and the viability of coral larvae could also be affected by expended materials.

The Navy will not conduct training or testing activities involving the use of explosives that could generate expended items within 350 yards of areas that have live hard bottom. The Navy recovers only a small portion of the items used during training and testing activities, meaning that a large quantity of marine debris is generated by these activities annually. While the 350-yard buffer will minimize some impacts to ESA-listed corals and elkhorn and staghorn coral critical habitat, we anticipate that there will still be impacts to these resources. However, because the area of habitat, including critical habitat, and associated ESA-listed coral colonies affected is extremely small (i.e., by several orders of magnitude) in relation to available habitat within these species' ranges, we do not anticipate the impacts of military expended materials will have population level effects to ESA-listed corals. Similarly, the impacts to designated critical habitat from the military expended materials is a very small fraction of the habitat in the action area and rangewide that is available to elkhorn and staghorn corals for settlement, growth, and sexual and asexual recruitment. We expect the rest of the habitat containing the essential feature in the action area and rangewide to continue providing these functions. Thus, recovery of these species in the action area or rangewide will not be delayed or made more difficult as a result of the military expended materials.

10 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

This section attempts to identify the likely future changes and their impact on ESA-listed species and their critical habitats in the action area. This section is not meant to be a comprehensive socio-economic evaluation, but a brief outlook on future changes in the environment. Projections are based upon recognized organizations producing best-available information and reasonable rough-trend estimates of change stemming from these data. However, all changes are based upon projections that are subject to error and alteration by complex economic and social interactions.

During this consultation, we searched for information on future state, tribal, local, or private (non-Federal) actions reasonably certain to occur in the action area. We did not find any information about non-Federal actions other than what has already been described in the *Environmental Baseline* (Section 8), most of which we expect will continue in the future. An increase in these activities could similarly increase their effect on ESA-listed resources and for some, an increase in the future is considered reasonably certain to occur. Given current trends in global population growth, threats associated with climate change, pollution, fisheries, bycatch, aquaculture, vessel strikes and approaches, and sound are likely to continue to increase in the future, although any increase in effect may be somewhat countered by an increase in conservation and management activities. In contrast, more historic threats such as whaling and sea turtle harvest are likely to remain low or potentially decrease. For the remaining activities and associated threats identified in the Environmental Baseline, and other unforeseen threats, the magnitude of increase and the significance of any anticipated effects remain unknown. The best scientific and commercial data available provide little specific information on any long-term effects of these potential sources of disturbance on ESA-listed species. Thus, this consultation assumed effects in the future would be similar to those in the past and, therefore, are reflected in the anticipated trends described in the status of the species (Section 7.2) and Environmental Baseline sections.

11 Integration and Synthesis

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 9) to the *Environmental Baseline* (Section 8) and the *Cumulative Effects* (Section 10) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the *Status of the Species and Critical Habitat* (Section 7.2).

The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered species and critical habitat that are likely to be exposed. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the actions considered in this opinion. While NMFS recognizes that Navy training and testing requirements change over time in response to global or geopolitical events and other factors, the general types of activities addressed by this consultation are expected to continue into the reasonably foreseeable future, along with the associated impacts. Therefore, our analysis in this opinion assumed that the training and testing activities proposed by the Navy during the period of NMFS' proposed incidental take authorization pursuant to the MMPA would continue into the reasonably foreseeable future at levels similar to those assessed in this opinion. Note that while the analysis assumes Navy activities, along with the associated impacts, will continue into the reasonably foreseeable future, the reinitiation triggers described in Section 15 apply.

11.1 Marine Mammals

Navy training and testing activities introduce a variety of stressors into the action area that are expected to result in adverse effects to ESA-listed marine mammals. Our effects analysis determined that sonar and other transducers, explosives, and vessel strike are likely to adversely affect ESA-listed marine mammals. We determined that vessel strike is likely to result in mortality to two ESA-listed marine mammals in the action area over the five year period of the proposed MMPA rule and into the reasonably foreseeable future, and established that a range of impacts including temporary and permanent threshold shift, behavioral response, and stress are likely to occur due to exposure to Navy acoustic stressors during training and testing events. In this section, we discuss the likely consequences of these effects to the cetaceans that have been exposed, the populations those individuals represent, and the species those populations comprise.

Our effects analyses identified the probable risks the Navy training and testing activities and issuance of an MMPA rule and LOA to authorize take of marine mammals would pose to ESA-listed individuals that will be exposed to these actions. We measure risks to individuals of endangered or threatened marine mammals using changes in the individual's "fitness" or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When we do not expect listed marine mammals exposed to an action's effects to experience reductions in fitness, we would not expect the action to have adverse consequences on the overall reproduction, abundance, or distribution of the populations those individuals represent or the species those populations comprise. As a result, if we conclude that listed animals are not likely to experience reductions in their fitness, we would conclude our assessment. If, however, we conclude that listed animals are likely to experience reductions in their fitness, we would assess the consequences of those fitness reductions for the population or populations the individuals in an action area represent.

As documented previously, many of the impacts resulting from the proposed action are from sounds produced during Navy training and testing activities in the action area. While this opinion relies on the best available scientific and commercial information, our analysis and conclusions include uncertainty about the basic hearing capabilities of some marine mammals; how these animals use sounds as environmental cues; how they perceive acoustic features of their environment; the importance of sound to the normal behavioral and social ecology of species; the mechanisms by which human-generated sounds affect the behavior and physiology (including the non-auditory physiology) of exposed individuals; and the circumstances that could produce outcomes that have adverse consequences for individuals and populations of exposed species. Based on the best available information, we expect most exposures and potential responses of ESA-listed cetaceans to Navy acoustic stressors to have little effect on the exposed animals. As is evident from the controlled exposure experiments and opportunistic research on the effects of sonar presented previously, responses are expected to be short-term, with the animal returning to normal behavior patterns shortly after the exposure is over (e.g., Goldbogen et al. 2013a; Silve et al. 2015). However, Southall et al. (2016) suggested that even minor, sub-lethal behavioral changes may still have significant energetic and physiological consequences given sustained or repeated exposure. As described in further detail in Section 9.2.1.1.4, we would expect an increased likelihood of consequential effects when exposures and associated effects are long-term and repeated, occur in locations where the animals are conducting critical activities, and when the animal affected is in a compromised state.

11.1.1 North Atlantic Right Whale

As described in further detail in Section 7.2, the endangered North Atlantic right whale is currently in decline in the western North Atlantic (Pace et al. 2017b) and experiencing an unusual mortality event (Daoust et al. 2017). Based on data available as of September 2017, there are estimated to be approximately 450 right whales in the western North Atlantic. Recent modeling efforts indicate that low female survival, a male-biased sex ratio, and low calving success are contributing to the population's current decline (Pace et al. 2017b). Due to the declining status of North Atlantic right whales, the resilience of this population to stressors that would impact the distribution, abundance, and reproductive potential of the population is low.

North Atlantic right whales are expected to experience TTS, behavioral disturbance, and physiological stress throughout the Atlantic coast from Navy sonar and other transducers. No injury (auditory or other) or mortality is expected from exposure to sonar and other transducers. Based on the Navy's modeling, a total of 451 instances of harassment (inclusive of TTS, behavioral disturbance, and stress) are reasonably certain to occur from Navy sonar annually. North Atlantic right whales are also expected to experience 18 instances of TTS from Navy explosives. Additionally, based on the best available information on the exposure of North Atlantic right whales to explosives, and as detailed in Section 9.2.1.2.2, no injury (auditory or other) or mortality to North Atlantic right whales is reasonably certain to occur. Additionally, no vessel strikes of North Atlantic right whales are anticipated.

As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate these instances of TTS and behavioral harassment to result in fitness consequences to individual North Atlantic right whales. Our analysis considered the overall number of exposures to acoustic stressors that are expected to result in behavioral harassment, TTS, and stress, the duration and scope of the proposed activities expected to result in such impacts, the expected behavioral state of the animals at the time of exposure, and the expected condition of those animals. Instances of North Atlantic right whale exposure to acoustic stressors in designated critical habitat (i.e., areas where we have more certainty on what activities the animals are conducting; foraging or calving) are expected to be short-term, with the animal returning to its previous behavioral state shortly thereafter. Some exposures to longer duration activities could occur outside of critical habitat areas, but because these activities occur over large geographic areas (e.g., Composite Training Unit Exercises can span from the coast of North Carolina to northern Florida, within the Virginia Capes and Jacksonville Range Complexes) the likelihood is low that animals and Navy activities will co-occur for extended periods of time or repetitively over the duration of an activity. As described previously, information is not available to conduct a quantitative analysis to determine the likely fitness consequences of these exposures and associated responses because we do not have information from wild cetaceans that links short-term behavioral responses to vital rates and animal health. Harris et al. (2017a) summarized the research efforts conducted to date that have attempted to understand the ways in which behavioral responses may result in long-term consequences to individuals and populations. Efforts have been made to try and quantify the potential consequences of such responses, and frameworks have been developed for this assessment (e.g., Population Consequences of Disturbance). However, models that have been developed to date to address this question require many input parameters and, for most species, there are insufficient data for parameterization (Harris et al. 2017a). Nearly all studies and experts agree that infrequent exposures of a single day or less are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015b; NAS 2017; New et al. 2014; Southall et al. 2007d; Villegas-Amtmann et al. 2015). Based on best available information, we expect this to be the case for North Atlantic right whales exposed to Navy acoustic stressors.

Because we do not anticipate fitness consequences to individual North Atlantic right whales to result from the proposed action, we do not expect the proposed action to result in reductions in overall reproduction, abundance, or distribution of the North Atlantic right whale population. For these reasons, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of North Atlantic right whales in the wild.

11.1.2 Blue Whale

As described further in Section 7.2, current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC 2007). Available information suggests increasing population growth rates in the eastern North Pacific (Calambokidis et al. 2009) and in the Southern Hemisphere (Branch 2007), but trend information is not available in the North Atlantic (Waring et al. 2010).

Blue whales are expected to experience TTS, behavioral response, and physiological stress throughout waters off the Atlantic coast from sonar and other transducers. Based on the Navy's modeling, a total of 46 instances of harassment are reasonably certain to occur from Navy sonar annually. Blue whales are also expected to experience one instance of TTS during the five year period of the proposed MMPA rule and into the reasonably foreseeable future due to explosives used during a large ship shock trial. No other blue whale impacts from explosives are anticipated. Based on the best available information on the exposure of blue whales to sonar and explosives, and as detailed in Section 9.2.1.2.2, no injury or mortality this species is reasonably certain to occur. Additionally, no vessel strike of blue whales is anticipated. As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate these instances of TTS and behavioral harassment to result in fitness consequences to individual blue whales. In addition, based on the best available information on the exposure of blue whales to ship strike (See Section 9.2.1.3.1), no injury or mortality of this species is reasonably certain to occur from this stressor.

It is also noteworthy that Navy training and testing activities similar to those proposed have been conducted in the action area for decades. Despite this, there have been no documented instances of human caused serious injury or mortality to blue whales in recent years (from any source, including military activities) and information is not available to suggest blue whale populations in this area are decreasing. While trend information is not available for blue whales in the North Atlantic, in the Eastern North Pacific, Monnahan et al. (2014) suggested that the blue whale population is at carrying capacity and recovered to pre-whaling levels. This is despite extensive Navy training and testing activities occurring in the eastern North Pacific (e.g., Hawaii-Southern California Training and Testing; Northwest Training and Testing; Gulf of Alaska training). Because these activities are the same or very similar to those proposed in the action area, this suggests, blue whales are likely resilient to any impacts incurred from these activities.

Because we do not anticipate fitness consequences to individual blue whales to result from the proposed action, we do not expect the proposed action to result in reductions in overall reproduction, abundance, or distribution of the blue whale population in the North Atlantic Ocean or range-wide. For these reasons, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of blue whales in the wild.

11.1.3 Fin Whale

As described in further detail in Section 7.2, of the three to seven stocks thought to occur in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in U.S. waters, where NMFS' best estimate of abundance is 1,618 individuals (NMFS 2017d). However, this may be an underestimate as the entire range of the stock was not surveyed (Palka 2012). According to the latest NMFS stock assessment report for fin whales in the Western North Atlantic, information is not available to conduct a trend analysis for this population (NMFS 2017d). Rangewide, there are over 100,000 fin whales occurring primarily in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere.

Fin whales are expected to experience PTS, TTS, behavioral disturbance, and physiological stress throughout the Atlantic coast from Navy sonar and other transducers. No non-auditory injury or mortality is expected from exposure to sonar and other transducers. Based on the Navy's modeling, a total of 5,083 instances of harassment (inclusive of TTS, behavioral disturbance, and stress) are reasonably certain to occur from Navy sonar annually and two instances of PTS. Fin whales are also expected to experience 70 instances of TTS from Navy explosives and 4 instances of PTS annually. Additionally, 27 instances of PTS and 234 instances of TTS are anticipated during the large ship shock trial proposed during the five year period of the MMPA rule, and each subsequent five year period. Three small ship shock trials are also proposed during the five year period of the MMPA rule and 3 instances of PTS and 131 instances of TTS are anticipated from each trial. Based on the best available information on the exposure of fin whales to explosives, and as detailed in Section 9.2.1.2.2, no non-auditory injury or mortality to fin whales is reasonably certain to occur. Additionally, based on the analysis in Section 9.2.1.3, we anticipate one vessel strike of a fin whale to occur during the five year period of the proposed MMPA rule, and during each subsequent five year period.

As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate that instances of TTS and behavioral harassment will result in fitness consequences to individual fin whales. Because we do not anticipate fitness consequences to individual fin whales to result from instances of TTS and behavioral harassment due to acoustic stressors, we do not expect these stressors to cause reductions in overall reproduction, abundance, or distribution of the fin whale population in the North Atlantic or rangewide.

Unlike TTS, PTS is permanent meaning the effects of PTS last well beyond the duration of the proposed action and outside of the action area as animals migrate. As such, PTS has the potential to affect aspects of affected animal’s life functions that do not overlap in time and space with the proposed action. As discussed previously in Section 9.2.1.2.4, permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness. Our exposure and response analyses indicate that some fin whales would experience PTS, but this PTS is expected to be minor due to the conservative methods used to calculate impacts and the Navy’s mitigation. With this minor degree of PTS, even though several individual whales are expected to experience a minor reduction in fitness, we would not expect such impacts to have meaningful effects at the population level given what is known about the current status of the fin whale population that will be exposed. That is, a few individual fin whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. For this reason, we do not anticipate that instances of PTS will result in changes in the number, distribution, or reproductive potential of fin whales in the North Atlantic.

We also anticipate Navy vessels will strike one fin whale over the five year period of the proposed MMPA rule, and during each subsequent five year period. As described in Section 9.2.1.3.1, we anticipate the animal impacted will die. Death would have a direct fitness consequence to the individual leading to lost reproductive potential that the individual might contribute to the population or sub-population. This lost reproductive potential will vary depending on the sex (male or female) and maturity of the individual. As stated previously, the fin whale population in the North Atlantic is approximately 50,000 individuals. Assuming a balanced sex ratio, this means 25,000 females likely exist in the North Atlantic. In the worst-case scenario, the one fin whale expected to be struck in the five years of the MMPA rule by Navy vessels would be female of early reproductive age. This would reduce the reproductive potential of this population by 0.004 percent. This is not an appreciable reduction in the numbers or the reproductive capability of fin whales in the North Atlantic Ocean. It is also worth noting that the North Atlantic population is a subset of the range-wide population of fin whales. Therefore, we also conclude that this level of mortality is not an appreciable reduction in the numbers or reproductive capability of the species range-wide.

It is also noteworthy that Navy training and testing activities similar to those proposed have been conducted in the action area for decades. Despite this, information is not available to suggest fin whale populations in this area are decreasing. While trend information is not available for fin whales in the North Atlantic, in the California Current, the fin whale population is showing strong signs of recovery and populations are increasing (NMFS 2017c). This is despite extensive Navy training and testing activities occurring in this area (e.g., Hawaii-Southern California Training and Testing; Northwest Training and Testing; Gulf of Alaska training) for many years. Because these activities are the same or very similar to those proposed in the action area, this suggests fin whales are likely resilient to impacts incurred from these activities.

In summary, the impacts expected to occur and affect fin whales are not anticipated to result in reductions in overall reproduction, abundance, or distribution of the fin whale population in the North Atlantic. Because we do not anticipate impacts to the fin whale population in the North Atlantic, we also do not anticipate reductions in overall reproduction, abundance, or distribution of the fin whale population rangewide. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of fin whales in the wild.

11.1.4 Sei Whale

The most recent abundance estimate we are aware of for sei whales is 25,000 individuals worldwide (Braham 1991). According to the latest NMFS stock assessment report for sei whales in the western North Atlantic, there are insufficient data to determine population trends for sei whales (NMFS 2016c). The best abundance estimate for the Nova Scotia stock of sei whales is 357 animals, though the abundance survey from which this estimate was derived excluded waters off the Scotian Shelf, an area encompassing a large portion of the stock's range. For this reason, this abundance estimate is considered a minimum. Outside of U.S. waters in the North Atlantic, a shipboard sighting survey of Icelandic and Faroese waters produced an estimate of about 10,300 sei whales (Cattanach et al. 1993). Additionally, Macleod et al. (2005) reported an estimated 1,011 sei whales in waters off Scotland.

Sei whales are expected to experience TTS, behavioral disturbance, and physiological stress throughout the Atlantic coast from Navy sonar and other transducers. No sei whale injury (auditory or otherwise) or mortality is expected from exposure to sonar and other transducers. Based on the Navy's modeling, a total of 767 instances of harassment (inclusive of TTS, significant behavioral disturbance, and stress) are reasonably certain to occur from Navy sonar annually. Sei whales are also expected to experience 7 instances of TTS from Navy explosives. Additionally, 4 instances of PTS and 27 instances of TTS are anticipated during the large ship shock trial proposed during the five year period of the MMPA rule. Three small ship shock trials are also proposed during the five year period of the MMPA rule and 1 instance of PTS and 12 instances of TTS are anticipated from each trial. Based on the best available information on the exposure of sei whales to explosives, and as detailed in Section 9.2.1.2.2, no non-auditory injury or mortality to sei whales is reasonably certain to occur. Additionally, based on the analysis in Section 9.2.1.3.1, we anticipate one vessel strike of a sei whale to occur during the five year period of the proposed MMPA rule, and during each subsequent five year period.

As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate that instances of TTS and behavioral harassment will result in fitness consequences to individual sei whales. Because we do not anticipate fitness consequences to individual fin whales to result from instances of TTS and behavioral harassment due to acoustic stressors, we do not expect these stressors to cause reductions in overall reproduction, abundance, or distribution of the sei whale population in the North Atlantic or rangewide.

Unlike TTS, PTS is permanent meaning the effects of PTS last well beyond the duration of the proposed action and outside of the action area as animals migrate. As such, PTS has the potential to effect aspects of the affected animal's life functions that do not overlap in time and space with the proposed action. As discussed previously in Section 9.2.1.2.4, permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness. Our exposure and response analyses indicate that some sei whales would experience PTS, but this PTS is expected to be minor due to the conservative methods used to calculate impacts and the Navy's mitigation. With this minor degree of PTS, even though several individual whales are expected to experience a minor reduction in fitness (e.g., less efficient ability to locate conspecifics; decreased ability to detect threats at long distance), we would not expect such impacts to have meaningful effects at the population level. That is, a few individual sei whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. For this reason, we do not anticipate that instances of PTS will result in changes in the number, distribution, or reproductive potential of sei whales in the North Atlantic.

We also anticipate Navy vessels will strike one sei whale over the five year period of the proposed MMPA rule, and during each subsequent five year period. As described in Section 9.2.1.3.2, we anticipate the animal impacted will die. Death would have a direct fitness consequence to the individual leading to lost reproductive potential that the individual might contribute to the population or sub-population. This lost reproductive potential will vary depending on the sex (male or female) and maturity of the individual. As stated previously, best available information suggests the rangewide sei whale population is approximately 25,000 individuals. For the North Atlantic, the most recent information available suggests there are at least 11,668 animals. Assuming a balanced sex ratio (Horwood 1987), this means 5,834 females likely exist in the North Atlantic. In the worst-case scenario, the one sei whale expected to be struck in five years by Navy vessels would be female of early reproductive age. This would reduce the reproductive potential of this population by 0.02 percent. This is not an appreciable reduction in the numbers or the reproductive capability of sei whales in the North Atlantic. The potential impact on the rangewide population of sei whales would be even lower. Therefore, we conclude that this level of mortality is not an appreciable reduction in the numbers or reproductive capability of the species in the North Atlantic or rangewide.

In summary, the impacts expected to occur and affect sei whales are not anticipated to result in reductions in overall reproduction, abundance, or distribution of the sei whale population in the North Atlantic. Because we do not anticipate impacts to the sei whale population in the North Atlantic, we also do not anticipate reductions in overall reproduction, abundance, or distribution of the sei whale population rangewide. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of sei whales in the wild.

11.1.5 Bryde's Whale – Gulf of Mexico Subspecies

As described in Section 7.2, the best abundance estimate for Gulf of Mexico Bryde's whales is 33 animals (NMFS 2015e). The Deepwater Horizon oil spill severely impacted Bryde's whales in the Gulf of Mexico, with an estimated 17 percent of the population killed, 22 percent of females exhibiting reproductive failure, and 18 percent of the population suffering adverse health effects (DWHTrustees 2016). For these reasons, the resilience of this population to stressors that could impact the distribution, abundance, and reproductive potential of the population is low.

Gulf of Mexico Bryde's whales are expected to experience TTS, behavioral response, and physiological stress in the Gulf of Mexico from sonar and other transducers. Based on the Navy's modeling, a total of 51 instances of harassment are reasonably certain to occur from Navy sonar annually. Gulf of Mexico Bryde's whales are also expected to experience four instances of TTS annually due to explosives and one Bryde's whale is anticipated to experience PTS every five years. Based on the best available information on the exposure of Gulf of Mexico Bryde's whales to sonar and explosives, and as detailed in Section 9.2.1.2.2, no non-auditory injury or mortality of this species is reasonably certain to occur. As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate these instances of TTS and behavioral harassment to result in fitness consequences to individual Bryde's whales. As discussed for the other large whale species, the single instance of PTS that is expected every five years is expected to be minor due to the conservative methods used to calculate impacts and the Navy's mitigation.

For example, during consultation, the Navy agreed to move the northern Gulf of Mexico ship shock trial box west, out of the Bryde's whale BIA, including a 5 NM buffer (Figure 16). This significantly limits the potential for a severe case of PTS to occur. With a minor degree of PTS, even though the individual whale is expected to experience a minor reduction in fitness (e.g., less efficient ability to locate conspecifics; decreased ability to detect threats at long distance), we would not expect such impacts to have meaningful effects at the individual or population level. That is, the individual whale could be slightly less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but the affected animal is still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. For this reason, we do not anticipate that this instance of PTS that is anticipated once every five years will result in changes in the number, distribution, or reproductive potential of Gulf of Mexico Bryde's whales.

In summary, the impacts expected to occur and affect Gulf of Mexico Bryde's whales are not anticipated to result in a reductions in overall reproduction, abundance, or distribution of this subspecies. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of Gulf of Mexico Bryde's whales in the wild.

11.1.6 Sperm Whale

As described in further detail in Section 7.2, the most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA listing. No other more recent rangewide abundance estimates are available for this species (NMFS 2015c). There are no reliable estimates for sperm whale abundance across the entire Atlantic Ocean. However, estimates are available for two of three U.S. stocks in the Atlantic Ocean, the Northern Gulf of Mexico stock, estimated to consist of 763 individuals (N_{min}=560) and the North Atlantic stock, underestimated to consist of 2,288 individuals (N_{min}=1,815). There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands stock.

Sperm whales are expected to experience TTS, behavioral response, and physiological stress throughout the Atlantic coast and in the Gulf of Mexico from sonar and other transducers. Based on the Navy's modeling, a total of 26,482 instances of harassment (i.e., 676 TTS and 25,806 behavioral disruptions) are reasonably certain to occur from Navy sonar annually. Sperm whales are also expected to experience 6 instances of TTS and 4 instances of behavioral response due to explosives annually. In addition, one sperm whale slight lung injury, 3 instances of PTS, and 3 instances of TTS are expected to occur during the large ship shock trial conducted during the five year period of the proposed MMPA rule. Finally, one instance of PTS and one instance of TTS are anticipated from each of the three small ship shock trial proposed for the five year period of the proposed MMPA rule and into the reasonably foreseeable future. We also anticipate the Navy to strike one sperm whale in the North Atlantic over the five year period of the proposed MMPA rule.

As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate that instances of TTS and behavioral harassment will result in fitness consequences to individual sperm whales. Because we do not anticipate fitness consequences to individual sperm whales to result from TTS and behavioral harassment due to acoustic stressors, we do not expect these impacts to cause reductions in overall reproduction, abundance, or distribution of the sperm whale population in the North Atlantic or rangewide.

Unlike TTS, PTS is permanent meaning the effects of PTS last well beyond the duration of the proposed action and outside of the action area as animals migrate. As such, PTS has the potential to effect aspects of the affected animal's life functions that do not overlap in time and space with the proposed action. As discussed previously, permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness. Our exposure and response analyses indicate that some sperm whales would experience PTS, but this PTS is expected to be minor due to the conservative methods used to calculate impacts and the Navy's mitigation. With this minor degree of PTS, even though several individual whales are expected to experience a minor reduction in fitness (e.g., less efficient ability to locate conspecifics; decreased ability to detect threats at long distance), we would not expect such impacts to have meaningful effects at the population level. That is, a few individual sperm whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. For this reason, we do not anticipate that instances of PTS will result in changes in the number, distribution, or reproductive potential of sperm whales in the North Atlantic.

As discussed in Section 9.2.1.2.4, to be protective in our consideration of the proposed action's effects, we assume the animal experiencing non-auditory injury by Navy explosives was a reproductively mature female and that the injury suffered reduced the ability of the affected animal to reproduce during the period of recovery. The inter-birth interval is generally 4-6 years for most sperm whales (NMFS 2015c). Because of this long period of time between births, we assume that the injured animal may miss, at most, one pregnancy. This represents a minor reduction in the reproductive potential of the sperm whale population, but given the high abundance of this species, this instance of non-auditory injury is not expected to result in meaningful impacts to the population's ability to reproduce and recover.

We also anticipate a Navy vessel will strike one sperm whale over the five year period of the proposed MMPA rule, and during each subsequent five year period. As described in Section 9.2.1.3.1, we anticipate the animal impacted will die. Death would have a direct fitness consequence to the individual leading to lost reproductive potential that the individual might contribute to the population or sub-population. This lost reproductive potential will vary depending on the sex (male or female) and maturity of the individual. As stated previously, the most recent abundance estimate for sperm whales in the North Atlantic stock was 2,288 individuals. The most recent rangewide abundance estimate is between 300,000 and 450,000 individuals (Whitehead 2009). Assuming a balanced sex ratio, this means at least 1,144 females in the North Atlantic stock (a subset of the population in the North Atlantic), and 150,000 females likely exist rangewide. In the worst-case scenario, the one sperm whale expected to be struck in the five years of the MMPA rule by Navy vessels would be female of early reproductive age. This would reduce the reproductive potential of the North Atlantic stock by 0.04 percent and of the rangewide population by 0.0007 percent. This is not an appreciable reduction in the numbers or the reproductive capability of sperm whales either in the North Atlantic or range-wide.

It is also noteworthy that Navy training and testing activities similar to those proposed have been conducted in the action area for decades. Despite this, information is not available to suggest sperm whale populations in the action area are decreasing and information suggests sperm whale populations rangewide are recovering. As noted above, recent abundance estimates indicate sperm whales may be approaching population sizes prior to commercial whaling, the reason for ESA listing.

In summary, the impacts expected to occur and affect sperm whales are not anticipated to result in reductions in overall reproduction, abundance, or distribution of the sperm whale population in the North Atlantic. Because we do not anticipate impacts to the sperm whale population in the North Atlantic, we also do not anticipate reductions in overall reproduction, abundance, or distribution of the sperm whale population rangewide. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of sperm whales in the wild.

11.2 Sea Turtles

The Navy's proposed training and testing activities will introduce a variety of stressors into the action area that are expected to result in adverse effects to ESA-listed sea turtles. Five species are expected to occur within the action area, including the North Atlantic DPS of green sea turtles, Kemp's ridley sea turtles, hawksbill sea turtles, leatherback sea turtles, and Northwest Atlantic DPS of loggerhead sea turtles.

Many of the impacts on sea turtles resulting from the Navy's proposed action are from acoustic (impulsive and non-impulsive) stressors, explosives, and vessel strikes. Other stimuli including, ingestion of expended materials or entanglement are not likely to adversely affect sea turtles given the characteristics of these stressors, frequency and expanse of the action area they would be dispersed in, densities of sea turtles, and likelihood that they would co-occur with Navy activities and encounter them.

While this biological opinion relies on the best available scientific and commercial information, our analysis and conclusions include uncertainty about the basic hearing capabilities of sea turtles, such as how they use sound to perceive and respond to environmental cues, and how temporary changes to their acoustic soundscape could affect the normal physiology and behavioral ecology of these species. Vessel strikes and encounters with underwater detonations (explosives) are expected to result in more significant effects on individuals than other stressors considered in this opinion. Those that are killed and removed from the population would decrease reproductive rates, and those that sustain non-lethal injuries and permanent hearing impairment could have fitness consequences during the time it takes to fully recover, or have long lasting impacts if permanently harmed. Temporary hearing impairment and significant behavioral disruption from harassment could have similar effects, but given the duration of exposures, these impacts are expected to be temporary and a sea turtle's hearing is expected to return back to normal after some healing duration. Therefore, these temporary effects are expected to exert significantly less adverse effects on any individual than severe injuries and permanent non-lethal injuries. We expect an increased likelihood of consequential effects when exposures and associated effects are long-term and repeated, and occur in locations where the sea turtles are conducting critical activities at the time of exposure.

In this, section we assess the likely consequences of these effects to the sea turtles that have been exposed, the populations those individuals represent, and the species those populations comprise. Section 7.2 described current sea turtle population statuses and the threats to their survival and recovery. Most sea turtle populations have undergone significant to severe reduction by human harvesting of both eggs and sea turtles, loss of beach nesting habitats, as well as severe bycatch pressure in worldwide fishing industries. The *Environmental Baseline* identified actions expected to generally continue for the foreseeable future for each of these species of sea turtle. Our conclusions for the ESA-listed species of sea turtles are discussed below.

11.2.1 Green Sea Turtle – North Atlantic DPS

We conclude that no green sea turtles would be injured or killed in any given year from explosive detonations. However, hearing impairment is expected, and up to eight green sea turtles could experience PTS per year, 19 over each five-year period. Up to 76 could experience TTS per year, 96 over each five-year period. These numbers assume that three ship shock trials could occur in one year or happen three times over a five-year period. Additionally, up to 5,076 green sea turtles could experience adverse behavioral effects, for a total of 25,380 over each five-year period. Many of these behavioral effects constitute harassment. However, behavioral responses of turtles to acoustic stressors is poorly studied, it is very difficult to determine exactly what percentage of these turtles would actually be harassed.

For those individual green sea turtles that could experience permanent hearing loss from acoustic stressors, we would expect some minor fitness consequence to an individual. Given that sea turtles generally are not considered to rely extensively on their hearing for important life functions, but rather rely more on visual cues and orientation with the Earth's magnetic field, a permanent change in an animal's ability to hear sound frequencies within their hearing bandwidths is not expected to result in consequences for the individual that would adversely affect the population dynamics, behavioral ecology, and social dynamics of green sea turtles.

However, these permanent changes in hearing could decrease an individual sea turtle's ability to detect danger such as approaching vessels or predators; and may reduce foraging or breeding opportunities or increase risks of sustaining other harm.

Temporary hearing impairment and significant behavioral disruption from harassment could have similar effects, but these impacts are expected to be temporary and a sea turtle's hearing is expected to return back to normal after some healing duration. Similarly, normal behaviors are anticipated to resume once exposure to the stressor ceases, unless the animal is subjected to repeated, prolonged exposures which could increase the risk of an animal sustaining injury. This would certainly be true for sustained periods of harassment. Even if take is non-lethal, the fleeing of the action area due to disturbance or avoidance of a stressor, can cause individuals to expend more energy seeking suitable habitat. This has the potential to result in reduced growth rates, older age to maturity, and lower lifetime fecundity. However, given that harassment occurring from Navy activities of green sea turtles is episodic and temporary we would not expect the most severe effects to be realized at a magnitude that would reduce an individual's fitness. An action that is not likely to reduce the fitness of individual turtles would not be likely to reduce the viability of the populations those individual turtles represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

During activities which require vessels, we anticipate up to four hardshell guild sea turtles (larger than 30 cm), which include green sea turtles or hawksbill sea turtles could sustain non-lethal injury from a vessel strike annually. However, given the low percentage of the hardshell guild comprised of hawksbill sea turtles, none of these non-lethal strikes are expected be of hawksbill sea turtles. We also estimated up to 11 green sea turtles could be killed annually from Navy vessel strikes. For small, less than 30 cm hardshell turtles (Kemps ridley, green, hawksbill and loggerhead sea turtles), we estimated a relative risk for non-lethal and lethal strikes to occur based upon large sea turtle densities, resulting in a small percentage of 0.007 hardshell guild sea turtles being injured, including green sea turtles annually. Up to 0.019 percent of small green sea turtles could be killed annually. This results with up to 20 large green sea turtles being injured and 55 killed; and up to 0.035 percent and 0.10 percent small green sea turtles could be killed over each five-year period of Navy training and testing activities. We assume that significant behavioral and stress responses could occur concurrent with being struck by a vessel for those sea turtles that do not sustain non-lethal strikes.

Because up to 55 green sea turtles could be killed from vessel strikes this is likely to exert some effect on the population numbers in the near-term in the action area. However, this estimated level of lethal take is likely the worst-case scenario. Even if this worst-case scenario did occur, this anticipated mortality level is not likely to impact the survival and recovery of the North Atlantic DPS green sea turtles, as these levels of mortality represent a small fraction (0.0004 percent) of the estimated adult population of the sea turtle species in the action area.

These impacts to the proportion of the green sea turtle population represents a highly conservative estimate based on several assumptions that went into the Navy's model and our risk assessment. No reduction in the distribution of the north Atlantic DPS of green sea turtles is expected from the take associated with the Navy's activities as green turtles will continue to be present throughout waters action area. Whether the potential reduction in numbers due to lethal serious non-lethal injury due to impacts to reproductive output would appreciably reduce the likelihood of survival of green sea turtles from the North Atlantic DPS depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. The North Atlantic DPS of green sea turtles is the largest of the 11 green turtle DPSs with an estimated abundance of over 167,000 adult females from 73 nesting sites. All major nesting populations demonstrate long-term increases in abundance (Seminoff et al. 2015b). We believe the proposed action is not reasonably expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of green sea turtles from the North Atlantic DPS in the wild. Although the potential mortality of turtles from this DPS may occur as a result of the impacts from the proposed activities, and would result in a reduction in absolute population numbers, the population of green sea turtles in the North Atlantic DPS would not be appreciably affected. For a population to remain stable, sea turtles must replace themselves through successful reproduction at least once over the course of their reproductive lives and at least one offspring must survive to reproduce itself. If the hatchling survival rate to maturity is greater than the mortality rate of the population, the loss of breeding individuals would be exceeded through recruitment of new breeding individuals from successful reproduction of non-taken sea turtles. Because the abundance trend information for green sea turtles is increasing, we believe the anticipated takes attributed to the proposed action will not have any measurable effect on that trend.

While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue for this DPS, they appear to be somewhat resilient to future perturbations. Therefore, we do not expect the impacts associated with any individual green sea turtles from the Navy's Phase III training and testing activities to reduce the viability of the green sea turtle populations those individual turtles represent in the long-term, and therefore we do not expect appreciable reductions in the reproduction, numbers, or distribution of those populations.

11.2.2 Hawksbill Sea Turtle

Based on our analysis of the effects of the Navy's Phase III training and testing activities that use explosives, we conclude that no hawksbill sea turtles would be injured or killed, or suffer PTS. However, temporary hearing impairment is expected, and up to 24 hawksbill sea turtles could experience TTS per year. Additionally, up to 317 sea turtles could experience adverse behavioral effects annually from exposure to explosives.

For those individuals that experience non-lethal injuries or temporary hearing loss, we would expect them to fully recover over some period of time and not sustain lasting impairment. While this may have an energetic cost to the individual for the time it takes to heal, we do not anticipate fitness consequences to an individual from temporary hearing loss over the long-term. These sea turtles are also expected to experience significant behavioral disturbance and could have a diminished ability to detect threats in their environment, or have temporary reduction in foraging efforts or other life functions. This would be intensified if sustained periods of harassment occurred. These periods of behavioral responses that may result in avoiding or leaving the area during Navy activities could cause individuals to expend more energy seeking suitable habitat elsewhere. This has the potential to result in reduced growth rates, older age to maturity, and lower lifetime fecundity. However, because Navy activities are episodic and temporary, we would not expect the most severe effects to be realized at a magnitude that would reduce an individual's fitness from temporary, albeit significant behavioral responses.

During Navy activities that involve vessels, we determined four hardshell guild sea turtles, which include green sea turtles or hawksbill sea turtles could sustain non-lethal injury from a vessel strike annually; and a very small percentage of only .007 of these sea turtles under 30 cm may be struck by a vessel. However, we do not anticipate for any hawksbill sea turtles to sustain a lethal vessel strike. We also assume that behavioral and stress responses could occur concurrent with being struck by a vessel for those sea turtles that are not killed by the vessel strike.

Because up to 20 hawksbill (as a portion of the hardshell guild) could be injured from Navy vessel strikes over each five year period of training and testing, there is the potential for some effect on the population numbers in the near-term in the action area, especially if the sustained injuries affect the reproductive health of any individual. However, as with green sea turtles, hawksbill sea turtles represent a proportion of the hardshell sea turtle guild and this estimated level of injury is likely the worst-case scenario. However, even if this worst-case scenario did occur, this anticipated injury level is not likely to impact the recovery of the hawksbill sea turtles, as these levels of injury represent a small fraction (.0002 percent) of the estimated population of this sea turtle species in the action area.

Because adult hawksbill turtles continue to face the threats described in our *Status of the Species* section (harvesting of turtles and eggs, fatal effects of lights on or adjacent to nesting beaches to emerging hatchlings), these species' resilience to additional perturbation is low. However, most of the recommended conservation measures for this species are focused on the protection of reef and nesting beach habitats. The Navy will implement mitigation measures to avoid sea turtle nesting beach areas and reef areas, as well as *Sargassum* mats. Whether the potential reduction in numbers due to lethal take or serious injury due to impacts to reproductive output would appreciably reduce the likelihood of survival of hawksbill sea turtles depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. There are currently no reliable estimates of population abundance and trends for non-nesting hawksbills at the time of this consultation. Therefore, nesting beach data is currently the primary information source for evaluating trends in abundance. Mortimer and Donnelly (2008) found that for nesting populations in the Atlantic, nine of the ten sites with recent data (the past 20 years) show nesting increases (especially within the Caribbean). With increasing nesting trends, we believe the losses expected due to the proposed action will be replaced due to increased nest production and the proposed action will not appreciably reduce hawksbill turtle's survival in the wild.

Despite the potential impacts to hawksbill sea turtles, few individuals are expected to be affected in such a manner as to reduce the viability of the populations those individual turtles represent. For these reasons we would not expect appreciable reductions in the reproduction, numbers, or distribution of hawksbill turtles from Navy activities.

11.2.3 Kemp's Ridley Sea Turtle

Based on our analysis of the training and testing activities that use explosives, we conclude that one Kemp's ridley sea turtle would be injured in the form of GI tract, lung or other physical injury over each five-year period from a large ship shock trial. Up to seven Kemp's ridley sea turtles could experience PTS per year and 19 over each five-year period of Navy training and testing. TTS could occur for 54 individuals per year, 66 over each five-year period. Additionally, up to 6,656 sea turtles could experience adverse behavioral effects, for a total of 33,280 over a five-year period of training and testing from exposure to explosives.

In addition, during Navy operations that use sonar, we expect one Kemp's ridley to suffer temporary hearing impairment per year. We also expect four Kemp's ridley sea turtles will be harassed annually from sonar sound.

We determined up to five Kemp's ridley sea turtles (four out of the hardshell guild and one for Kemp's ridley alone) could sustain serious injury from a vessel strike, and up to four could be killed annually. For smaller Kemp's ridley sea turtles (less than 30 cm), we estimate up to 0.007 percent could experience non-lethal strike and up to .03 percent could be killed annually. Thus, a total of 25 Kemp's ridley sea turtles could be injured, and 20 could sustain lethal injury and die over each five year period of Navy training and testing. Additionally, a low percentage of sea turtles smaller than 30 cm would be injured or killed (0.04 and 0.15 percent respectively) over each five year period of training and testing. We assume that behavioral and stress responses could occur concurrent with being struck by a vessel for those sea turtles that are not killed by the vessel strike.

Because Kemp's ridley sea turtles are endangered and continue to face the threats described in Sections 0 and 8, such as fisheries bycatch and harvesting, this species is more vulnerable to new sources of mortality or impacts which affect individual ability to reproduce and contribute to the populations recovery, therefore, resilience to future perturbation is considered low for Kemp's ridley sea turtles compared to other sea turtles. However, the 20 Kemp's ridley sea turtles that could be killed from vessel strikes and explosives represent a very small percentage of the Kemp's ridley population in the action area. Thus although there would be a loss of individuals to contributing to the population, the number of reproductively successful females and average clutch size of eggs is expected to be able to replace the loss of this small percentage of sea turtles in the future.

Whether the potential reduction in numbers due to lethal serious non-lethal injury due to impacts to reproductive output would appreciably reduce the likelihood of survival of Kemp's ridley sea depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. The Kemp's ridley sea turtle female nesting abundance at a single site in the Gulf of Mexico region has declined significantly from an estimated 40,000 females in 1947 to 300 nesting females by the mid-80's. However, more recent nesting counts in this same region have shown an increase. In 2014, there were an estimated 10,987 nests and 519,000 hatchlings released from three primary nesting beaches in Mexico and counts have also increased over the past two decades in nesting beaches within Texas (NMFS and USFWS 2015). We believe the proposed action is not reasonably expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of Kemp's ridley sea turtles in the wild. Although the potential mortality of turtles from this species may occur as a result of the impacts from the proposed activities, and would result in a reduction in absolute population numbers, the population of Kemp's ridley sea turtles in the overall action area would not be appreciably affected. For a population to remain stable, sea turtles must replace themselves through successful reproduction at least once over the course of their reproductive lives and at least one offspring must survive to reproduce itself. If the hatchling survival rate to maturity is greater than the mortality rate of the population, the loss of breeding individuals would be exceeded through recruitment of new breeding individuals from successful reproduction of non-taken sea turtles. Because the abundance trend information for Kemp's ridley turtles show an increased number of hatchlings in more recent years, we believe the anticipated takes attributed to the proposed action will not have any measurable effect on that trend.

For those individual Kemp's ridley sea turtles that could experience permanent hearing loss, we would expect some minor fitness consequence to an individual. It is possible these permanent changes in hearing could decrease a sea turtle's ability to detect danger such as approaching vessels or predators; and may reduce foraging or breeding opportunities or increase other risks of sustaining harm. However, as described already, since sea turtles generally are not considered to rely extensively on their hearing for important life functions, a permanent change in a sea turtle's hearing ability is not expected to result in consequences for the individual that would adversely affect the population dynamics, behavioral ecology, and social dynamics of Kemp's ridley sea turtles.

Temporary hearing impairment and significant behavioral disruption from harassment could have similar effects, but these impacts are not expected to persist, and a sea turtle's hearing is expected to return back to normal after some period of time. Similarly, normal behaviors are anticipated to resume once exposure to the stressor ceases, unless the animal is subjected to repeated, prolonged exposures which could increase the risk of an animal sustaining additional harm. Even if take is non-lethal, the avoidance or fleeing of the action area due to exposure to a stressor, can cause individuals to expend more energy seeking suitable habitat. This has the potential to result in reduced growth rates, older age to maturity, and lower lifetime fecundity. Given that harassment of Kemp's ridley sea turtle occurring from Navy activities of Kemp's ridley sea turtles is episodic and temporary, we would not expect the most severe effects to be realized at a magnitude that would reduce an individual's fitness. Therefore, we do not expect the small amount of lethal take (across five years) and temporary impacts associated with any individual Kemp's ridley sea turtles from the Navy's training and testing activities to reduce the viability of the population these individual turtles represent. For these reasons, we would not expect reductions in overall reproduction, abundance, or distribution of the Kemp's ridley populations in the action area over the long-term. We believe the proposed action is not reasonably expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of Kemp's ridley sea turtles in the wild**.**

11.2.4 Loggerhead Sea Turtle – North Atlantic DPS

The expected impacts to loggerhead sea turtles from explosives occurring annually during the Navy's Phase III training and testing activities could result in mortality of four loggerhead sea turtles (i.e., two from annual activities; one from small ship shock trials; and one from large ship shock trials), and up to 26 could be injured per year. Twelve are expected to be killed over a five-year period of training and testing and a total of 42 could suffer injury in the form of GI tract, lung or other injury. Additionally, up to 111 loggerheads could experience PTS per year, and 275 over each five-year period. TTS could occur for 1,386 individuals per year, 1,730 over a five-year period. Additionally, up to 46,171 loggerhead sea turtles could experience adverse behavioral effects annually, for a total of 230,855 over a five-year period.

During Navy operations that use sonar, we expect six loggerhead sea turtles to suffer temporary hearing impairment in the form of TTS per year, and up to 30 for each five-year period. We also expect 34 loggerheads to be harassed from sonar sound, for a potential total of 170 over the duration of the program. In addition, the use of small air guns will harass up to two loggerheads, for a total of 10 over the course of each five-year period. Up to seven loggerhead turtles per year and 35 over each five year period could experience significant behavioral disruption due to exposure to received impulsive sound during pile driving for the Elevated Causeway.

We expect up to 11 loggerhead sea turtles could be injured, and 15 could be killed from vessel strikes annually during Navy activities. An additional 0.004 percent of smaller (less than 30 cm) loggerhead sea turtles could sustain non-lethal, and 0.009 percent lethal vessel strikes.

Across all stressors, 79 loggerhead sea turtles could be killed from vessel strikes and explosives. NMFS does not expect this to have population level consequences because this mortality rate represents only 0.0004 percent of the current North Atlantic DPS of loggerhead within the action area. This may result in a slight reduction in reproduction rates, but over the long-term we do not expect this small percentage to appreciably reduce the viability of the population those individual turtles represent throughout their range.

For the 97 sea turtles that may be injured from explosives and vessel strikes over each five year period, we do not know what the severity of the injuries would be, nor if they would die sometime later if they do not fully recover from those injuries. However, many of the injuries are expected to be non-lethal, and therefore a sea turtle may survive to reproduce and contribute to the species recovery. There would be a fitness consequence possible, especially if the injuries affected a sea turtles ability to carry-out important life functions such as foraging or avoiding predators.

Up to 275 loggerhead sea turtles could sustain permanent hearing loss. However as described above, sea turtles are not thought to rely substantially on their hearing compared to other senses such as vision to detect environmental cues. It is possible these permanent changes in hearing could decrease a sea turtle's ability to detect danger such as approaching vessels or predators and could reduce foraging or breeding opportunities or increase other risks of sustaining harm. A permanent change in a sea turtle's hearing ability is not expected to result in consequences for the individual that would adversely affect the population dynamics, behavioral ecology, and social dynamics of loggerhead sea turtles.

Up to 1,736 loggerhead sea turtles that could suffer temporary hearing impairment, and we also assume these turtles would have physiological stress. These temporary conditions are expected to return to normal over a short period of time. Additionally, 231,070 loggerhead turtles may be harassed or exhibit other behavioral responses from exposure to acoustic stressors. However, these changes in behavior are not expected to persist for a long time post-exposure to this stressor. These temporary alterations in behavior are not likely to reduce the overall fitness of individual turtles and would not be likely to reduce the viability of the populations those individual turtles represent. Thus, we would not expect reductions in the reproduction, numbers, or distribution of those populations from TTS, stress, harassment by sonar, air guns or explosives exposure. However, if a single loggerhead is exposed more than once, these effects would last for a longer duration, or the severity (such as degree of TTS) could increase and take long to recover from. In general, based upon what we know about sound effects on sea turtles, we do not anticipate exposure to these acoustic stressors to have long term effects on an individual nor alter critical life functions. Therefore, we do not anticipate loggerhead sea turtles to have population level consequences from acoustic stressors.

Although lethal, and non-lethal but serious, injury could reduce reproductive potential from the pool of reproductive adults from Navy training and testing activities, we do not expect these reductions to appreciably reduce the likelihood of survival or recovery of the species in the wild. A preliminary regional abundance survey of loggerheads within the northwestern Atlantic continental shelf, corrected for unidentified turtles in proportion to the ratio of identified turtles, estimates about 801,000 loggerheads (NMFS-NEFSC 2011). More recent nesting data indicate that nesting in Georgia, South Carolina, and North Carolina is now on an upward trend. The Northwest Atlantic Ocean DPS of loggerhead sea turtles are at continued risk from loss of nesting habitat, reduced nest counts, and continued mortality of juveniles and adults from fishery bycatch. Although we anticipate a small (0.1) percent of lethal take (across five years) along with associated temporary impacts of loggerhead sea turtles from Navy training and testing activities during each five year period, this represents a small percentage of the overall population of loggerhead sea turtles. Therefore, we do not expect these effects to reduce the viability of the population these individual turtles represent; as we do not expect reductions in overall reproduction, abundance, or distribution of the loggerhead populations in the action area over the long-term.

11.2.5 Leatherback Sea Turtle

Based on our analysis of Navy training and testing activities, we conclude that five leatherback sea turtles could be injured over each five-year period from explosives. These injuries are expected to be in the form of GI tract, lung, and other physical injuries. Additionally, up to 36 leatherbacks could experience PTS per year and 43 over a five-year period from exposure to explosives. TTS could occur for 731 individuals per year. Additionally, up to 3,297 leatherback sea turtles could experience adverse behavioral effects, for a total of 16,485 over a five-year duration from the use of explosives. Many of these behavioral effects could constitute harassment. However, behavioral responses of turtles to acoustic stressors is poorly studied and it is very difficult to determine exactly what percentage of these turtles would be harassed. Nonetheless, we assume a subset of these individuals will be displaced or have their behavior altered to such an extent that may increase their risk for other adverse effects such as predation, reduced foraging effort, etc. During Navy operations that use sonar, we expect one leatherback sea turtle to suffer temporary hearing impairment in the form of TTS per year, and up to five for each five-year period. We also expect two leatherbacks to be harassed from sonar annually.

We also expect up to three leatherback sea turtles to be injured and one to be killed annually from Navy vessel strikes. An additional 0.008 percent of smaller (less than 30 cm) leatherback sea turtles could sustain non-lethal injuries; and up to 0.002 percent could be killed from vessel strikes. Over a five-year period of Navy training and testing activities, up to 15 leatherback sea turtles could be killed from vessel strikes, and 30 injured from vessel strikes and explosives. These numbers represent 0.0002 percent mortality of the population in the action area, which is very low compared to the range-wide population. Since leatherback sea turtles continue to face the threats described in our *Status of the Species* and *Environmental Baseline* sections, such as climate change, fisheries bycatch and harvesting, they are considered to have lower resilience to additional perturbation than some other sea turtle species. Although we anticipate a small (0.0002) percent of lethal take (across five years) along with associated temporary impacts of leatherback sea turtles from Navy training and testing activities during each five year period, this represents a small percentage of the overall population of leatherback sea turtles.

Non-lethal injuries, hearing impairment and behavioral harassments, could affect a sea turtle's ability to detect danger such as approaching vessels or predators; and cause a reduction in foraging opportunities or other life functions. Temporary hearing impairment and significant behavioral disruption from harassment could have similar effects, but these impacts are not expected to persist, and a TTS is expected to return back to normal after some healing duration. Similarly, normal behaviors are anticipated to resume once exposure to the stressor ceases, unless the animal is subjected to repeated, prolonged exposures which could increase the risk of an animal sustaining injury. Given that harassment occurring from Navy activities of leatherback sea turtles is episodic and temporary we would not expect the most severe effects to be realized at a magnitude that would reduce an individual's fitness.

While lethal take and serious non-lethal injury of adult leatherbacks is anticipated occur and would affect reproduction rates, the overall leatherback sea turtle population in the action area is stable. The leatherback Turtle Expert Working Group estimates there are between 34,000 – 95,000 total adults (20,000 – 56,000 adult females; 10,000 – 21,000 nesting females) in the North Atlantic. The review by NMFS USFWS (2013) suggests the leatherback nesting population is stable in most nesting regions of the Atlantic Ocean. Therefore, we do not expect the impacts associated with the Navy's Phase III training and testing activities to reduce the viability of the population those individual turtles represent and we would not expect significant reductions in the reproduction, abundance, or distribution of the leatherback sea turtles. We believe the proposed action is not reasonably expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of leatherback sea turtles in the wild.

Summary of Effects on Sea Turtles

Given the current status of the ESA-listed sea turtle populations in the action area and the potential risk from acoustic exposures, explosives and vessel strikes, the Navy will implement several mitigation measures intended to reduce the risk that Navy activities may pose to ESA-listed sea turtles. These mitigation measures will reduce the risk that Navy activities may pose to ESA-listed sea turtles. Based on the analysis above, the potential to kill or significantly injure sea turtles is relatively low compared to the likelihood of non-lethal effects such as PTS, TTS, and behavioral harassment.

All life stages are important to the survival and recovery of a species. However, it is important to note that individuals of one life stage are not equivalent to those of other life stages. For example, the take of male juvenile sea turtles may affect survivorship and recruitment rates into the reproductive population in any given year and yet not significantly reduce the reproductive potential of the population. Yet, the death of mature, breeding females can have an immediate effect on the reproductive rate of a species. Sublethal effects on adult females may also reduce reproduction by hindering forage success, as sufficient energy reserves are probably necessary for producing multiple clutches of eggs in a breeding year. Different age classes may be subject to relative rates of mortality, resilience, and overall effects of population dynamics. Ontogenetic shifts, or changes in location and habitat, can have a major impact on where sea turtles occur and what human hazards they may encounter. Based on some sea turtle population modeling efforts, the reduction of mortality in early age classes is likely to positively affect population dynamics by increasing cohort size (Mazaris et al. 2005). A shift in diet for all sea turtles occurs when juvenile sea turtles shift to a neritic habitat and benthic feeding, at which time they would become more susceptible to impacts.

We expect individual sea turtles to be killed from exposure to explosives and vessel strikes, and others to be injured and suffer fitness consequences from those injuries. The Navy's proposed action may reduce foraging or reproductive ability of individuals that suffer these fitness consequences. However, as described above and throughout this biological opinion, given the current status of the sea turtle populations in the action, along with the baseline in the action area, the loss of a small percentage of individuals or fitness consequences to any single individual is not expected to translate to population or species-level consequences. The activities undertaken Navy's Phase III training and testing activities have been occurring in the action area for the last few decades and sea turtle population trends appear generally stable or increasing, which may indicate some level of population resilience to the activities being conducted. As such, the proposed action is not likely to reduce appreciably the likelihood of the survival and recovery of any ESA-listed sea turtles in the wild by substantially reducing their abundance, reproduction rates, or distribution. Therefore, we do not expect that the proposed action will reduce the likelihood of both the survival and recovery of an ESA-listed sea turtle species in the action area.

11.3 Fishes

The Navy's proposed training and testing activities introduce a variety of stressors into the action area that are expected to result in adverse effects to ESA-listed fishes. Many of the impacts to ESA-listed fishes resulting from the Navy's proposed action are from explosives. Vessel strikes of sturgeon are also likely to occur. Other stimuli described in this biological opinion are not likely to adversely affect fishes given the characteristics of these stressors, frequency and expanse of the action area they would be dispersed in, the distribution and lifestage of fishes, and likelihood of co-occurrence with Navy activities in the action area.

While this biological opinion relies on the best available scientific and commercial information, our analysis and conclusions include uncertainty about the abundance of fishes in the action area that would likely be exposed to these stressors and behavior of fishes when exposed. Those that are killed and removed from the population would decrease reproductive rates, and those that sustain non-lethal injuries could have fitness consequences during the time it takes to fully recover, or have long lasting impacts, if permanently harmed. Temporary hearing impairment and significant behavioral disruption have the potential to result in similar effects, but these impacts are expected to be temporary and a fish's hearing is expected to return back to normal after some healing duration. While this may have an energetic cost to the individual for the time it takes to heal, we do not anticipate fitness consequences to an individual fish from temporary hearing loss over the long-term. Fish could have a diminished ability to detect threats in their environment, or have temporary reduction in foraging efforts or other life functions while they recover. This would be intensified if sustained periods of harassment or multiple exposures occurred. These periods of behavioral responses that may result in avoiding or leaving the immediate location of the exercise during Navy activities could cause individuals to expend more energy seeking suitable habitat elsewhere. This has the potential to result in reduced growth rates, older age to maturity, and lower lifetime fecundity. However, because Navy activities are episodic and temporary, we would not expect these effects to be realized at a magnitude that would reduce an individual's fitness from temporary behavioral responses.

Therefore, these temporary effects are expected to exert significantly less adverse effects on any individual than severe injuries and permanent non-lethal injuries. We would expect an increased likelihood of consequential effects if exposures and associated effects are long-term and repeated, and occur in locations where fishes are conducting critical activities at the time of exposure.

In this, section we assess the likely consequences of these effects to the fishes that have been exposed, the populations those individuals represent, and the species those populations comprise. The *Species and Critical Habitat Likely to be Adversely Affected* section described current fish population statuses and the threats to their survival and recovery. Our conclusions for the ESA-listed species of fish are discussed below.

11.3.1 Atlantic Salmon – Gulf of Maine DPS

The primary stressor likely to adversely affect Atlantic salmon is exposure to explosive detonations. Exposure to a blast could result in lethal and non-lethal take of individuals. Although we do not have a way to quantify how many Atlantic salmon could be killed by Navy activities, we expect lethal take for a small number of individuals that could be located within the blast radius of the detonations. Fish within these zones could be killed instantaneously, suffer severe injuries, experience TTS, or behavioral disruptions. They could also be temporarily disoriented which could increase their risk of predation or sustaining other harm. Any TTS or behavioral disruptions are considered temporary and not expected to linger to an extent that would affect an individual salmon's fitness. This may have an energetic cost to the individual for the time it takes to heal and could affect a fish's ability to detect threats in their environment, or have a reduced ability to carry out other important life functions. This has the potential to result in reduced growth rates, older age to maturity, and lower lifetime fecundity. However, because Navy activities are episodic and temporary, we would not expect the most severe effects to be realized at a magnitude that would reduce an individual's Atlantic salmon's fitness from temporary behavioral responses.

The only lifestage of Atlantic salmon expected to be exposed to explosives would be adult salmon, which could be present during seasonal migrations in the spring and summer. Since adult salmon presence is expected to be limited to the late spring and early summer months, exposures would only be expected during this time of year. It is worth noting that most Gulf of Maine DPS Atlantic salmon spawn in freshwater habitats flowing into the Gulf of Maine. For most Atlantic salmon, their migratory route in marine waters includes the Gulf of Maine, and areas to the north and east. As described in Section 3.4.2.2.2, the Navy will not conduct in-water detonations in the Gulf of Maine and explosives will also not generally be used in portions of the action area to the north and east of the Gulf of Maine, so the vast majority of returning Atlantic salmon would not be exposed to explosives.

The Gulf of Maine DPS of Atlantic salmon has experienced declines in abundance, and long-term population trends suggest a negative growth rate. Human-induced factors have caused population decline, including overexploitation, degradation of water quality, damming of rivers, and coastal development, all of which remain persistent threats. Climate change may cause changes in prey availability and thermal niches, further threatening Atlantic salmon populations. Even with current conservation efforts, returns of adult Atlantic salmon to the Gulf of Maine DPS rivers remain low compared to historical levels.

While lethal, and non-lethal but serious, injury could reduce reproductive potential, the loss of a very small percentage of adults from Navy training and testing activities over time is not expected to appreciably decrease the number of returning adults in the future because of the number of juveniles produced by these populations. Since no spawning or freshwater rearing habitat will be affected by the Navy's proposed activities, impacts on spawning success and survival from egg to juvenile are not expected. In addition, it is presumed adult salmon not harmed or killed could continue to spawn in future years and produce juveniles to replace any individuals lost during Navy activities. This is particularly true since the Navy will not conduct in-water detonations in the Gulf of Maine, the primary portion of the action area where this DPS could occur in marine waters. The primary threats to Gulf of Maine DPS are described above. Despite Navy activities occurring in the action area for decades, military training and testing activities have not been identified as a threat to the survival or recovery of this species. For these reasons, the abundance, distribution, and reproduction of the Gulf of Maine DPS of Atlantic salmon is not likely to be appreciably reduced by Navy training and testing activities conducted over the five year period of the proposed MMPA rule, or into the reasonably foreseeable future. Therefore, we do not anticipate the Navy's Phase III training and testing activities to preclude the survival or recovery of Atlantic salmon in the wild.

11.3.2 Atlantic Sturgeon

Within the action area, five Atlantic sturgeon DPSs may be exposed to sound and energy from explosives and pile driving, and vessel strikes associated with activities throughout the year. These include the threatened Gulf of Maine DPS, the endangered New York Bight, Chesapeake, Carolina, and South Atlantic DPSs of Atlantic sturgeon. No juvenile or larval sturgeon are expected to be present in the action area during any of the Navy's activities that use explosives. Therefore, the only life stages NMFS anticipates will be present are adult and sub-adult Atlantic sturgeon.

As with Atlantic salmon, any sturgeon located within the blast radius of an explosion could be injured or killed, and sustain some degree of TTS or exhibit behavioral disruptions. Severity of injury would likely increase closer to the blast, where mortality is more probable within a close distance of the blast radius of the largest bin sizes described in Section 9.2.3.2. (e.g., E8 and E11). It is the larger bin sizes that have a greater distance from the blast radius to reach potential effects, although the average bin size these fish are more likely to be exposed to come from the smaller bins (because explosives from smaller bins are used much more frequently). This reduces the area of habitat in the water column they could be present to incur these impacts. Typically, adult and sub-adult Atlantic sturgeon occur within nearshore training areas in the Northeast, Virginia Capes, Navy Cherry Point, and Jacksonville Range Complexes, and particularly in the Chesapeake Bay, but could also occur in some offshore areas along the continental shelf during certain times of the year. Since there are relatively few explosive activities in these nearshore areas throughout a given year and the size of explosives used for training activities in this area all belong to smaller bin sizes, the largest area of impact where onset of injury is expected is an average of 467 m (maximum of 1,275 m) from the detonation. Instantaneous mortality would not be expected beyond an average of 57 m from the source (maximum of 70 m). For testing activities involving explosions in this area, larger explosives could be used (in, or below, E2 or E3, with occasional detonations of bins E8 and E11). Based upon the range to effects from bin E11, the range to effects for TTS would be less than 3,152 m, (maximum 8,525 m), onset of injury at less than 9,705 m (maximum 25,775 m), and mortality at 1,075 m (maximum 2,775 m). However, the use of these larger bin sizes would occur less frequently than the smaller ones, so the most likely impacts would be associated with the smaller bins, which have much smaller ranges to mortality and injury.

As noted previously, information is not available to estimate the number of individual Atlantic sturgeon that are likely to be killed, injured, experience TTS, or behavioral disruption from explosives. However, based on best available information on Atlantic sturgeon habitat use and where most Navy explosives are used, only a very small percentage of individuals from the Atlantic sturgeon DPSs are anticipated to be exposed to and affected by this stressor. Much of this species' life history is spent outside of the action area either in freshwater habitats where explosives are not used or in nearshore locations where explosive activities are not common or where only small explosives with small ranges to mortality will be used. The Navy also has mitigation in place for some locations (e.g., Gulf of Maine, nearshore areas off the coast of Florida and Georgia) that limits or prohibits explosive use. While these measures are implemented to minimize impacts to marine mammals, these measures would also reduce the potential for impacts to Atlantic sturgeon in some nearshore habitats of the action area. Because Navy explosive use is intermittent with effects that do not span a large area (e.g., most explosives used in the action area, particularly in the nearshore portions of the action area where sturgeon are most likely to occur, have a range to mortality of < 100 m), we anticipate that most sturgeon in the action area would not co-occur with explosive stressors within the range to adverse effects described earlier in this opinion.

For pile driving, although the degree and number of individuals affected is expected to be less than those from explosives, Atlantic sturgeon could be harmed during construction of an Elevated Causeway. Atlantic sturgeon could also incur TTS or exhibit behavioral responses if located within the zones correlating to these impacts; these are a maximum distance of 870 m for lethal and non-lethal injury, TTS or behavioral responses. Severity of injury would increase closer to the pile, where mortality is more probable within 50 m of the pile, and some fish could sustain lethal and non-lethal injuries within 87 m of the pile, and TTS anywhere within those zones out to the 870 m distance. Further away from the pile out to a distance of 3,511 m, non-injurious effects could also occur such as a range of behavioral responses.

In addition, a small number of Atlantic sturgeon could be struck by Navy vessels and suffer mortality or be injured. We conservatively estimated up to one Atlantic sturgeon could be killed by a vessel strike in nearshore areas (excluding Chesapeake Bay) of the action area during each five year period. For the Chesapeake Bay region, we estimate up to one could be killed annually, most likely from the Chesapeake or Carolina DPSs. This results in a total of six potential lethal takes of Atlantic sturgeon from vessel strikes throughout the action area.

Atlantic sturgeon continue to be at risk from human-induced threats such as degraded water quality, habitat impacts from dredging, bycatch in state and federally managed fisheries, and vessel strikes. Based on the evidence available, including the environmental baseline and cumulative effects, and despite our inability to quantify the amount or extent of take from explosives or pile driving exposures, we conclude that the loss of a small percentage of sub-adult or adult sturgeon from these stressors is not expected to appreciably decrease the number of returning adults in the future. This is because the species is long-lived, produces a high number of juveniles, and because we anticipate such a small percentage of each DPS to be exposed to and affected by Navy activities. Since no Atlantic sturgeon spawning or freshwater rearing habitat will be affected by the Navy's proposed activities, impacts on spawning success and survival from egg to juvenile are not expected. In addition, adult sturgeon not harmed or killed could continue to spawn in future years and produce juveniles to replace any individuals lost during Navy activities. Any TTS or behavioral disruptions are considered temporary and not expected to linger to an extent that would affect an individual fish's fitness. This may have an energetic cost to the individual for the time it takes to recover, and therefore, a reduced ability to detect threats in their environment, or carry out other important life functions. However, because Navy activities are episodic and temporary we would not expect the most severe effects to be realized at a magnitude that would reduce an individual Atlantic sturgeon's fitness from temporary behavioral responses.

Therefore, the abundance, distribution, and reproduction of the threatened Gulf of Maine DPS, the endangered New York Bight, Chesapeake, Carolina, and South Atlantic DPSs of Atlantic sturgeon is not likely to be appreciably reduced by Navy training and testing activities in the action area. We believe the proposed action is not reasonably expected to cause, directly or indirectly, a reduction in the likelihood of survival and recovery of Atlantic sturgeon in the wild.

11.3.3 Giant Manta Ray

Giant manta ray could be present throughout the action area during Navy activities. Of the stressors we determined to likely adversely affect this species, we consider giant manta rays to be at the greatest risk from exposure to explosives during Navy activities. Giant manta rays have the highest probability of being exposed to explosives beyond 3 NM from shore within the Virginia Capes, Jacksonville, and Navy Cherry Point Range Complexes due to the relatively higher amount of activities that occur in these areas. In other areas such as the Gulf of Mexico, Northeast, and Key West Range Complexes, they have a lower probability of exposure.

In general, we consider giant manta rays to be less sensitive to underwater sound pressures produced from acoustic sources than fishes with swim bladders (e.g., Atlantic salmon). Nonetheless, they could suffer the suite of effects already described for other fish species, such as mortality, non-lethal injury, stress and behavioral disruptions from exposure to explosive detonations. Giant manta rays could be exposed to a range of charge sizes, but the majority of the explosives used in the ranges they may occupy are below E6 bin sizes with occasional detonations of larger charge sizes of bins E9, 10, 11 and 12. For these larger bins, the largest zone for range to potential effects from explosives exposure used during both training and testing is an average distance of 2,758 m (maximum 17,275 m) for injury, with a potential mortality range of 701 m (maximum 1,025 m) from the source. Giant manta rays also have the potential to be exposed to ship shock trials, which involve the largest net explosive weights. However, these activities occur infrequently with no more than three small and one large shock trial over each five-year period of Navy training and testing. Due to the infrequency of these activities and that this species is relatively rare in the action area (see below), the likelihood of giant manta ray exposure to these events is relatively low.

As noted previously, information is not available to estimate the number of individual giant manta rays that are likely to be killed, injured, experience TTS, or behavioral disruption from explosives. However, based on best available information on the distribution of giant manta rays and where most Navy explosives are used, only a very small percentage of the giant manta ray population is anticipated to be exposed to and affected by Navy explosives. In the Atlantic Ocean, very little information is available on giant manta ray populations, though there is a known protected population within the Flower Garden Banks National Marine Sanctuary. Very limited Navy activities occur in this area. Use of explosives is particularly unlikely in this area due to the Navy's mitigation to not conduct activities using explosives within 350 yards of coral reef habitats (See Table 39). In other areas of the Atlantic, information on the presence of giant manta rays comes from fisheries bycatch data, though this species is not commonly observed as bycatch in Atlantic fisheries (NMFS 2016a). For example, based on data from the NMFS shark bottom longline observer program, between 2005 and 2014, only two giant manta rays were observed caught by bottom longline vessels fishing in the Gulf of Mexico and South Atlantic (NMFS 2016a). Because encounters with this species in fisheries in the action area are not common, we would also anticipate impacts to this species from Navy activities to be a rare occurrence.

Giant manta rays could suffer mortality or serious injuries from exposure to Navy activities, though as documented above, we anticipate instances of injury or mortality to not be common. We are not able to determine what gender or lifestage could be harmed. Any behavioral disruptions or responses are considered temporary and not expected to linger to an extent that would affect an individual's fitness. This may have an energetic cost to the individual for the time it takes to heal and could affect a fish's ability to detect threats in their environment, or have a reduced ability to carry out other important life functions. This can result in reduced growth rates, older age to maturity, and lower lifetime fecundity. However, because Navy activities are episodic and temporary, we would not expect the most severe effects to be realized at a magnitude that would reduce an individual giant manta ray's fitness from temporary behavioral responses.

Because giant manta rays only produce pups every two to three years (average of 15 over the lifetime of a female), the loss of reproducing females would be of higher concern. The death of mature, breeding females could have an immediate effect on the reproductive rate of a species, depending on the magnitude of anticipated impact compared to population levels. Sublethal effects on adult female giant manta rays may also reduce reproduction by hindering forage success, as sufficient energy reserves are probably necessary to produce pups every few years. However, due to the rarity of presence of this species in the vast majority of the action area, and the wide distribution of Navy activities through the action area, we assume lethal take of giant manta rays would be a relatively low number. Although we are not able to quantify the amount of lethal take that could occur for giant manta rays, because the species are long-lived, and have a high adult survival rate, we assume any juvenile or adults that survives exposure to acoustic stressors would be able to replace the few individuals potentially killed by Navy activities in future years. Therefore, the abundance, distribution, and reproduction of the giant manta rays is not likely to be appreciably reduced by the associated effects of the Navy's Phase III AFTT training and testing activities. For these reasons we do not expect the proposed action to result in a reduction in the likelihood of survival and recovery of giant manta rays in the wild.

11.3.4 Oceanic Whitetip Shark

Within the action area, we concluded oceanic whitetip sharks are at risk of exposure to explosives used during Navy activities. This species is generally found in deeper offshore waters and has the highest likelihood of being exposed to explosives beyond the 3 NM offshore range within the Virginia Capes, Jacksonville, Navy Cherry Point, and Gulf of Mexico Range Complexes, with a lower probability of exposure in the Northeast and Key West Range Complexes. Since this species spends much of their time at the water surface, they would be more at risk of exposure from surface detonations (relative to bottom detonations). Similar to other fish species, if oceanic whitetip sharks are exposed, they could suffer mortality, injury, and hearing loss; as well as physiological stress or behavioral reactions.

The majority of the explosives used where Oceanic whitetip sharks could be present are in bins E6 or smaller, with occasional detonations of larger charge sizes (e.g., bins E9, 10, 11 and 12). The smaller bin sizes have correspondingly smaller ranges to injury or mortality. The largest zone for range to effects from explosives exposure from annual activities is based upon the distance from bin E12, corresponding to the onset of physical injury of an average distance of 2,758 m, with a potential mortality range of 701 m from the source. Ship shock trails occur offshore and use large net explosive weight, thus could result in the largest area of impact for oceanic whitetip sharks. However, as discussed previously, these are limited in number over each five-year period of Navy activities. Due to the dispersed, infrequent occurrence and short duration of explosives used throughout the ranges, and the rarity of oceanic whitetip shark presence, this species is unlikely to be exposed multiple times and instances of adverse effects would are not expected to be common. For this reason, though instances of lethal, and non-lethal injury have the potential to reduce reproductive potential for oceanic whitetip sharks permanently, we do not expect explosive use to appreciably reduce the likelihood of survival of the species in the wild. Similar to other fish species (and turtles), the loss of a small percentage of adults is not expected to appreciably decrease the ability of successful reproduction in the future. Adults not harmed or killed would continue to reproduce in future years and produce juveniles to replace any individuals lost during Navy activities.

In the Northwest Atlantic, throughout the action area, oceanic whitetip sharks are considered relatively rare. Thus, we anticipate impacts to oceanic whitetip sharks from Navy activities to not be common, particularly since this species does not possess a swim bladder making it less susceptible to injury or mortality from explosives than some other fish species. Moreover, due to spatial extent of the action area, and infrequent occurrence and short duration of explosives used throughout the Navy ranges where these sharks may occur, they are unlikely to be exposed multiple times within a short period of time. Thus, for these reasons, and although we cannot quantify how many oceanic whitetip sharks could be killed from explosives, we anticipate the number to be low. Any temporary effects such as stress or behavioral disruptions are not expected to result in long term consequences, and would return to normal shortly after the explosives exposure.

Primary threats to oceanic whitetip sharks are bycatch in commercial fisheries and direct harvest for the international shark fin trade. Navy activities have not been identified as a threat to this species' survival or recovery.

In summary, based on the information provided above, the abundance, distribution, and reproduction of oceanic whitetip sharks is not expected to be appreciably reduced by the associated effects of the Navy's Phase III AFTT training and testing activities and we do not expect a reduction in the likelihood of survival and recovery of oceanic whitetip shark in the wild.

11.3.5 Gulf Sturgeon

Gulf sturgeon may be injured, killed, suffer TTS, physiological stress, or behavioral effects from exposure to explosives, and could be injured or killed from vessel strikes. The only lifestage likely affected by these stressors are adult and sub-adult Gulf sturgeon because no juveniles are expected to be present in areas where Navy activities take place. In addition, the Navy will avoid conducting line charge testing in the Panama City Division Testing Range (except on Santa Rosa Island), between October and March. This will help avoid migration periods of Gulf sturgeon during that time as they transit to natal rivers of the Yellow, Choctawhatchee River, and Apalachicola River. This is expected to reduce the risk of exposure for individuals in that area.

Similar to other fish species considered in this opinion, the severity of adverse effects would be expected to increase the closer a sturgeon is located to the blast. The majority of the explosives used in areas where Gulf sturgeon could occur are in E4 or E6, with rare detonations of larger charge sizes (e.g., bin E10 or E14). Gulf sturgeon are not expected to be exposed to ship shock trials. Any Gulf sturgeon located within range to effects average distance of 5,025 m (maximum

30,525 m) could be injured or killed, with a higher chance of mortality occurring within 511 m (maximum of 925 m), and TTS possible within 860 m (maximum of 7,775 m) from the blast. In addition, we expect stress or behavioral responses to also occur if individuals are located within any of these distances. Any TTS, behavioral or stress responses may have an energetic cost to the individual for the time it takes to recover, and therefore a reduced ability to detect threats in their environment, or carry out other important life functions during that time.

As noted previously, information is not available to estimate the number of individual Gulf sturgeon that are likely to be killed, injured, experience TTS, or behavioral disruption from explosives. However, based on best available information on the distribution of this species and where most Navy explosives are used, instances of adverse effects are not expected to be common and only a very small percentage of the Gulf sturgeon population is anticipated to be exposed to and affected by this stressor. The vast majority of Navy activities considered in this opinion do not occur within the range of Gulf sturgeon (i.e., most activity is concentrated along the Atlantic coast, as opposed to in the Gulf of Mexico). Additionally, as noted above, Navy activities will not occur in Gulf sturgeon freshwater spawning or rearing habitats, and the Navy's mitigation at the Panama City Division Testing Range will reduce the risk of adverse effects from explosives for this species.

We anticipate a Navy vessel will also strike one Gulf sturgeon over each five year period of training and testing activities. If a sturgeon is hit by a Navy vessel we expect for it to sustain lethal or non-lethal injuries.

In general, Gulf sturgeon populations in the eastern portion of their range within the Gulf of Mexico appear to be stable or slightly increasing, while populations in the western portion are associated with lower abundances and higher uncertainty. Thus, the long term population viability of Gulf sturgeon is currently uncertain. Gulf sturgeon will continue to face the threats previously discussed into the foreseeable future such as habitat loss associated with dams and sills, habitat degradation associated with dredging, de-snagging, and contamination by pesticides, heavy metals, and other industrial contaminants. Effects of climate change may also lead to accelerated changes in the habitats utilized by Gulf sturgeon. Navy activities have been occurring in the action area for decades, but effects from these activities have not been identified as a primary threat to this species. Because Gulf sturgeon are long-lived species, adults can reproduce more than once, and no juveniles or spawning habitats are likely to be affect by the Navy's activities, we expect future reproduction and recruitment to replace any individuals lost from adverse effects during Navy activities. Any temporary effects such as stress or behavioral disruptions are not expected to be persistent, and are anticipated to return to normal shortly after the exposure and not cause long-term consequences. For these reasons, the abundance, distribution, and reproduction of Gulf sturgeon is not expected to be appreciably reduced by the effects of the Navy's Phase III AFTT training and testing activities. We do not expect for the proposed action to result in a reduced likelihood of survival and recovery of Gulf sturgeon .

11.3.6 Scalloped Hammerhead Shark – Central and Southwest Atlantic DPS

The stressor that we determined to pose the greatest risk to scalloped hammerhead sharks is exposure to explosives. However, since the habitat for the Central and Southwest Atlantic DPS of scalloped hammerhead shark occurs only within a small southern portion of the action area, the likelihood of this species encountering explosives is low. The vast majority of scalloped hammerheads sharks from this DPS would not likely be exposed to Navy activities. If exposure did occur, it would occur for individuals located in the Key West or southern portion of the Jacksonville Range Complex. Although there is a very low probability of scalloped hammerhead sharks being exposed to explosives due to their distribution in the action area, if they were within close enough proximity to a blast, they could suffer mortality or injury.

Information is not available to estimate the likely number of individual Central and Southwest Atlantic DPS scalloped hammerhead sharks that are likely to be killed, injured, or experience behavioral disruption from explosives due to lack of information on location and abundance of this species in the action area during Navy training and testing activities. However, as noted previously and below, only a very small percentage of individuals from this population are anticipated to be exposed to and affected by explosives. The action area is at the northern extent of this species' range and most scalloped hammerheads from the Central and Southwest Atlantic DPS likely do not occur in the action area during any portion of their life history. It is presumed any adult scalloped hammerheads not harmed or killed could continue to reproduce in future years and produce juveniles to replace any individuals lost during Navy activities. Moreover, due to spatial extent of the action area, and infrequent occurrence and short duration of explosives used throughout the Navy ranges where these sharks may occur, individual sharks are unlikely to be exposed multiple times within a short period of time. Any behavioral or stress responses may have an energetic cost to the individual for the time it takes to recover, and therefore a reduced ability to detect threats in their environment, or carry out other important life functions during that time. However, these temporary effects are not expected to be persistent, and would return to normal shortly after the explosives exposure. We do not anticipate behavioral disruptions will have fitness consequences to affected individuals.

In general, scalloped hammerhead shark populations within the action area appear to be stable and rebuilding. Primary threats to this species in the action area includes overutilization by commercial/industrial fisheries and high at-vessel fishing mortality. Navy activities have not been identified as a threat to this species' survival or recovery. In summary, based on the best available information, the loss of a small percentage of this population spread across a number of years is not expected to appreciably decrease the reproductive potential of this DPS. Therefore, the abundance, distribution, and reproduction of Central and Southwest Atlantic DPS scalloped hammerhead sharks is not likely to be appreciably reduced by Navy training and testing activities in the action area. Therefore, we do not anticipate the Navy's activities to reduce appreciably the likelihood of the survival or recovery of Central and Southwest Atlantic DPS scalloped hammerhead sharks in the wild.

11.3.7 Smalltooth Sawfish

We anticipate explosives may result in lethal and non-lethal take of smalltooth sawfish that are present in the action area during Navy activities. As with other fish species exposed to explosive detonations, we assume any smalltooth sawfish located within the range to effects of a detonation could be injured, killed, or experience physiological stress and behavioral responses. Because adult sawfish typically spend most of their time in shallow habitats rather that deeper waters, they are unlikely to be exposed to most of the Navy's activities using explosives since the vast majority of these exercises takes place offshore. However, adult sawfish can occur in more open-water, marine habitats, and would be the lifestage most likely affected by explosives. Additionally, the vast majority of Navy activities considered in this opinion do not occur within the range of this species.

Most of the explosives used in these ranges can be categorized into small bin sizes (e.g., E5). Based on the average and maximum distances for bin E5, any smalltooth sawfish that are present could be killed or injured if located within a range to the distance for onset of injury of less than 1,112 m (maximum 4,025 m) with a mortality range of 163 m (maximum of 330 m) from the source for the single cluster, and less than 1,112 m (maximum 4,025 m), with a mortality zone of 163 m (maximum 330 m), for the largest 25-cluster size. However, due to short duration of explosives, dispersed use throughout the ranges where smalltooth sawfish may be present, they are unlikely to be exposed multiple times within a short period of time, and would be expected to recover from minor non-lethal injuries. Any physiological stress or behavioral reactions would be expected to be brief and return to normal once a detonation ceases, although there could be an energetic cost for an individual fish during the time it takes for normal stress levels or behaviors to resume.

Because adult smalltooth sawfish are the life stage most likely affected by explosives use, the loss of reproducing females would be the highest concern. The death of mature, breeding females can have an immediate effect on the reproductive rate of the population. Sublethal effects on adult female smalltooth sawfish may also reduce reproduction by hindering foraging success, as sufficient energy reserves are necessary to produce offspring. Additionally, because they only produce between 10-20 pups, the loss of a reproducing female would be a greater concern than for other fish species which produce high numbers of offspring. However, because of the rarity of this species in the vast majority of the action area, particularly in locations where most Navy explosives are used, the likelihood of lethal take for this species is very low. Although we are not able to quantify the amount of adverse impacts that could occur for smalltooth sawfish, we assume any adults that survive exposure to acoustic stressors would be able to replace the few individuals potentially killed by Navy activities in future years. Therefore, the abundance, distribution, and reproduction of the smalltooth sawfish is not expected to be appreciably reduced, as we would not expect reductions in the reproduction, numbers, or distribution of these populations.

11.4 Corals and Elkhorn and Staghorn Critical Habitat

As described further in Section 7.2, the ESA-listed corals that are likely to be adversely affected by the proposed action face a number of common threats including ocean warming, ocean acidification, diseases, the trophic effects of fishing, sedimentation, and nutrient enrichment. Several of these threats that are contributing to the extinction risk of corals are related to global climate change.

Our effects analysis determined that military expended materials are likely to adversely affect ESA-listed corals in the action area. As discussed in Section 9.2.4, we do not have site-specific information that would allow us to determine the number of ESA-listed coral colonies of each species that will be impacted by Navy activities. Instead, we rely on an estimate of the habitat area affected by the proposed action as a surrogate for the number of individual coral colonies affected. The ESA-listed corals considered in this opinion consist of many thousands, if not millions, of colonies, occur across a range of thousands of miles, and occur outside of U.S. jurisdictions (Table 122).

Table 122. Known geographic distribution and abundance of ESA-listed corals in the action area.

Species	Known distribution	Abundance estimate (number of colonies)
Elkhorn coral (*A. palmata*)	Western Atlantic Ocean, Caribbean Sea, Gulf of Mexico	Hundreds of thousands*
Staghorn coral (*A. cervicornis*)	Western Atlantic Ocean, Caribbean Sea, southwestern Gulf of Mexico	Tens of millions*
Pillar coral (*D. cylindrus*)	Western Atlantic Ocean, Caribbean Sea	Tens of thousands*
Rough cactus coral (*M. ferox*)	Western Atlantic Ocean, Caribbean Sea	Hundreds of thousands*
Lobed star coral (*O. annularis*)	Western Atlantic Ocean, Caribbean Sea, Gulf of Mexico	Tens of millions*
Mountainous star coral (*O. faveolata*)	Western Atlantic Ocean, Caribbean Sea, Gulf of Mexico	Tens of millions*
Boulder star coral (*O. franksi*)	Western Atlantic Ocean, Caribbean Sea, Gulf of Mexico	Tens of millions*

**Minimum abundance information comes from the Final Rule to list 20 species of coral under the Endangered Species Act (79 FR 53851). For these species, the Rule lists an abundance estimate for a subset of areas within the range of the species. The Rule then states that the absolute abundance is higher than this estimate given the presence of the species in many other areas throughout its range.*

Relative to each species' geographic distribution, a very small area of habitat (by several orders of magnitude) that could contain ESA-listed species will be impacted annually by Navy training and testing activities. Navy activities that could affect ESA-listed corals are also concentrated in established Navy range complexes, but the vast majority of ESA-listed corals occur outside of these range complexes and will not be affected by the proposed action. For these reasons (i.e., small and concentrated area affected), we do not anticipate the proposed action to result in an appreciable effect on the distribution of the ESA-listed coral species considered in this opinion.

Within the areas of habitat affected, we anticipate there will be a reduction in numbers of ESA-listed coral colonies, though because a very small area of habitat relative to each species' distribution is likely to be affected, we anticipate this reduction in abundance of ESA-listed corals to not have an appreciable effect on species overall species abundance. Because we anticipate a reduction in the numbers of ESA-listed coral colonies, there is also the potential for a loss of reproductive potential for these species because these lost adult coral colonies would not produce future recruits. If the proposed action were to result in a measurable impact on reproductive potential, the proposed action would have the potential to impact the survival and recovery of the species. However, as noted in Section 9.1.5.4.1, larval coral survival may be only one percent, meaning that a very small fraction of the larvae that would have been produced by the affected coral colonies would have survived to settle on hard substrate and begin to grow into a coral colony. Additionally, because only a small fraction of the habitat area within each of these species' range will be affected (and therefore only a small fraction of the coral colonies within each species range), we do not anticipate the proposed action would have a measurable effect on the production of future ESA-listed coral recruits. For these reasons, we do not anticipate the small reductions in numbers to have a measurable effect on each species' reproductive potential.

In summary, the proposed action will adversely affect habitat within the distribution of ESA-listed corals, which could contain ESA-listed coral colonies. However, we do not anticipate the proposed action to result in changes in ESA-listed coral species distribution. We anticipate small reductions in abundance in the areas of habitat where ESA-listed corals occur, but as described above, we do not anticipate measurable effects from the proposed action on any ESA-listed species' reproductive potential. For these reasons, we do not anticipate the proposed action will impact the survival or recovery of the ESA-listed corals considered in this opinion.

The proposed action is also anticipated to result in a very small area of impact to designated critical habitat for elkhorn and staghorn coral. Impacts to critical habitat are expected from military expended materials. Whether the effects of the action will appreciably diminish the conservation value of critical habitat depends on the impacts on designated critical habitat as a whole, not just in the area where the action takes place. The question we must ask is whether the adverse effects in that one part of the critical habitat (i.e., within the action area) will diminish the conservation value of the critical habitat overall in such a manner that we can discern a difference in the recovery prospects of the species due to the effects of the action. For example, if we conclude that the effects of the proposed action on designated critical habitat will delay recovery, or make recovery more difficult or less likely, we will conclude the effects of the project are likely to destroy or adversely modify designated critical habitat.

Elkhorn and staghorn coral critical habitat covers approximately 7,663 km^2 of habitat in the southeastern United States and Caribbean. The proposed action is anticipated to affect a very small portion of this habitat and the habitat that Navy activities could affect, are concentrated in established Navy range complexes. The vast majority of coral critical habitat occurs outside of these range complexes. The impacts to designated critical habitat from the proposed action is a very small fraction of the habitat in the action area and rangewide that is available to elkhorn and staghorn corals for settlement, growth, and sexual and asexual recruitment. We expect the rest of the habitat containing the essential feature in the action area and rangewide to continue providing these functions. Thus, recovery of these species in the action area or rangewide will not be delayed or made more difficult as a result of the proposed action. Therefore, we believe that the proposed action will not destroy or adversely modify designated *Acropora* critical habitat for elkhorn and staghorn coral.

12 Conclusion

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the blue whale, fin whale, North Atlantic right whale, Gulf of Mexico Bryde's whale (proposed), sei whale, sperm whale, green turtle – North Atlantic DPS, hawksbill turtle, Kemp's ridley turtle, leatherback turtle, loggerhead turtle – Northwest Atlantic DPS, Atlantic salmon – Gulf of Maine DPS, Atlantic sturgeon – New York Bight DPS, Atlantic sturgeon – Chesapeake Bay DPS, Atlantic sturgeon – Carolina DPS, Atlantic sturgeon – South Atlantic DPS, Gulf sturgeon, giant manta ray, oceanic whitetip shark, scalloped hammerhead shark – Central and Southwest Atlantic DPS, smalltooth sawfish, elkhorn coral, staghorn coral, pillar coral, rough cactus coral, lobed star coral, mountainous star coral, and boulder star coral. It is also NMFS' biological opinion that the proposed action is not likely to destroy or adversely modify the designated critical habitat of elkhorn and staghorn coral.

13 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. In the case of threatened species, section 4(d) of the ESA leaves it to the Secretary's discretion whether and to what extent to extend the statutory 9(a) ‘‘take’’ prohibitions, and directs the agency to issue regulations it considers necessary and advisable for the conservation of the species.

"Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. NMFS had not yet defined "harass" under the ESA in regulation, but has issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering." We considered NMFS' interim definition of harassment in evaluating whether the proposed activities are likely to result in harassment of ESA-listed species. Incidental take statements serve a number of functions, including providing reinitiation triggers for all anticipated take, providing exemptions from Section 9 liability for prohibited take, and identifying reasonable and prudent measures that will minimize the impact of anticipated incidental take.

When an action will result in incidental take of ESA-listed marine mammals, ESA section 7(b)(4) requires that such taking be authorized under the MMPA section 101(a)(5) before the Secretary can issue an ITS for ESA-listed marine mammals and that an ITS specify those measures that are necessary to comply with Section 101(a)(5) of the MMPA. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS, including those specified as necessary to comply with the MMPA, Section 101(a)(5). Accordingly, the terms of this ITS and the exemption from Section 9 of the ESA become effective only upon the issuance of MMPA authorization to take the marine mammals identified here. Absent such authorization, this ITS is inoperative for ESA-listed marine mammals. Recall that this consultation analyzed the effects of two actions: 1) the Navy's Phase III AFTT training and testing activities and 2) NMFS Permits Division's promulgation of regulations pursuant to the MMPA for the Navy to "take" marine mammals incidental to AFTT activities. The amount or extent of take of marine mammals described below are applicable to both the Navy and NMFS Permits Division.

At the time of this consultation, take prohibitions have not been extended to the threatened Central and Southwest Atlantic DPS of scalloped hammerhead shark or the threatened species of Caribbean corals. However, consistent with we assessed the amount or extent of take to these threatened species that is anticipated incidental to Navy training and testing activities and include this information in the ITS. Inclusion of these species in the ITS serves to assist the action agency with monitoring of take and provides a trigger for reinitiation if levels of estimated take are exceeded.

13.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions. Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (e.g., similarly affected species or habitat or ecological conditions) may be used to express the amount or extent of anticipated take.

The following tables list the anticipated take from training and testing activities by species and the interrelated and interdependent actions of issuance of a five-year regulation and LOAs by NMFS' Permits Division to authorize take of marine mammals pursuant to the MMPA.

Table 123. The number of lethal and non-lethal takes of threatened and endangered marine mammals, sea turtles, and fish likely to occur annually as a result of the proposed Navy training and testing activities in the action area.

ESA-Listed Species	Impulsive and Non-Impulsive Acoustic Stressors				Vessel Strike	
	Harassment (TTS/Behavioral)	Harm (PTS)	Harm (Slight Lung Injury)	Mortality	Mortality[1]	Harm (non-lethal injuries) annually
Cetaceans						
North Atlantic Right Whale	266 / 203	-	-	-	-	-
Blue Whale	34 / 12	-	-	-	-	-
Bryde's Whale – Gulf of Mexico subspecies[1]	28 / 24	-	-	-	-	-
Fin Whale	3,437 / 1,716	6	-	-	1	-
Sei Whale	529 / 245	-	-	-	1	-
Sperm Whale	682 / 25,810	-	-	-	1	-
Sea Turtles						
Green – North Atlantic DPS	40/5,076	6	-	-	55	4
Hawksbill	313/24	-	-	-	-	4
Kemp's ridley	28/6,660	5			20	5
Loggerhead	772/46,178	80	17	2	75	11
Leatherback	348/3,299	22	2	-	5	3
Fishes						
Atlantic Sturgeon – Gulf of Maine DPS	-[3]	-[3]	-[3]	-[3]	1[4]	-
Atlantic Sturgeon – New York Bight DPS	-[3]	-[3]	-[3]	-[3]	1[4]	-
Atlantic Sturgeon – Chesapeake Bay DPS	-[3]	-[3]	-[3]	-[3]	6[4]	-
Atlantic Sturgeon – Carolina DPS	-[3]	-[3]	-[3]	-[3]	6[4]	-
Atlantic Sturgeon – South Atlantic DPS	-[3]	-[3]	-[3]	-[3]	1[4]	-
Gulf sturgeon	-[3]	-[3]	-[3]	-[3]	1	-

[1]*Numbers presented represent total exempted over a five-year period.*
[2]*Gulf of Mexico Bryde's whale is proposed. Take exemption only applies if the listing is finalized as proposed.*
[3]*See paragraph below regarding the extent of take of ESA-listed fish from the proposed action.*
[4]*For vessel strike of Atlantic sturgeon, no more than six total Atlantic sturgeon vessel strikes combined from all DPSs are exempted over a five-year period.*

Table 124. The number of lethal and non-lethal takes of threatened and endangered marine mammals and sea turtles likely to occur as a result of exposure to small ship shock trials conducted in the action area (i.e., up to three small ship shock trials could occur every five years).

ESA-Listed Species	Small Ship Shock Trials			
	Harassment (TTS)	Harm (PTS)	Harm (Slight Lung Injury)	Mortality
Marine Mammals				
North Atlantic Right Whale	3	-	-	-
Blue Whale	-	-	-	-
Bryde's Whale – Gulf of Mexico subspecies[1]	-	-	-	-
Fin Whale	393	9	-	-
Sei Whale	36	3	-	-
Sperm Whale	3	3	-	-
Sea Turtles				
Green – North Atlantic DPS	18	1	-	-
Hawksbill	2	-	-	-
Kemp's ridley	12	1	1	-
Loggerhead	339	19	5	1
Leatherback	169	7	1	-

[1]Gulf of Mexico Bryde's whale is proposed. Take exemption only applies if the listing is finalized as proposed.

Table 125. The number of lethal and non-lethal takes of threatened and endangered marine mammals and sea turtles that are likely to occur as result of exposure to a large ship shock trial conducted once every five years in the action area.

ESA-Listed Species	Large Ship Shock Trial			
	Harassment (TTS)	Harm (PTS)	Harm (Slight Lung Injury)	Mortality
Marine Mammals				
North Atlantic Right Whale	2	-	-	-
Blue Whale	1	-	-	-
Bryde's Whale – Gulf of Mexico subspecies[1]	3	1	-	-
Fin Whale	234	27	-	-
Sei Whale	27	4	-	-
Sperm Whale	3	3	1	-
Sea Turtles				
Green – North Atlantic DPS	18	1	-	-
Hawksbill	2	1	-	-
Kemp's ridley	15	1	1	-
Loggerhead	283	13	4	1
Leatherback	215	7	2	-

[1]Gulf of Mexico Bryde's whale is proposed. Take exemption only applies if the listing is finalized as proposed.

When it is not possible or practicable to specify the amount or extent of take, a surrogate may be used if we: describe the causal link between the surrogate and take of the listed species, explain why it is not practical to express the amount or extent of anticipated take or to monitor take-related impacts in terms of individuals of the listed species, and set a clear standard for determining when the level of anticipated take has been exceeded. 50 C.F.R. 402.14(g)(7)(i). As described previously in Section 9.2.3, for the proposed action, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take of ESA-listed fish species or to monitor take-related impacts in terms of individuals of these species due to the lack of data on fish density and abundance in the action area. Therefore, the surrogate for incidental take of ESA-listed fishes is expressed as a distance to reach effects in the water column that correlates with injury and sub-injury from acoustic stressors in those areas occupied by fishes. In other cases, as with vessel strikes we provide relative percentage of potential take for Atlantic sturgeon DPSs in relation to Navy vessel traffic occurrence within the action area (See Table 123).

As described previously in Section 9.2.4, for the proposed action, it is not possible, nor would it be an accurate representation of likely effects, to express the amount of anticipated take of ESA-listed corals as numbers of colonies, or to monitor take-related impacts in terms of individual colonies of these species. Therefore, the incidental take of ESA-listed corals is expressed as a habitat area surrogate as prescribed by 50 CFR 402.14(i). Anticipated take of ESA-listed corals is 0.00003 km^2 of habitat annually that may be occupied by live hard coral cover, a subset of which would be occupied by ESA-listed corals. This area of live coral cover is likely to be vulnerable to impacts from military expended materials used during training and testing activities.

Activity Levels as Indicators of Take for Marine Mammals and Sea Turtles

As discussed in this opinion, the estimated take of ESA-listed sea turtles and marine mammals from acoustic stressors is based on Navy modeling, which represents the best available means of numerically quantifying take. As the level of modeled sonar or explosive use increases, the level of take is likely to increase as well. For non-lethal take from acoustic sources specified above, feasible monitoring techniques for detecting and calculating actual take at the scale of AFTT activities do not exist. We are not aware of any other feasible or available means of determining when estimated take levels may be exceeded. Therefore, we must rely on Navy modeling, and the link between sonar or explosive use and the level of take, to determine when anticipated take levels have been exceeded. As such, we established a term and condition of this Incidental Take Statement that requires the Navy to report to NMFS any exceedance of activity specified in the preceding opinion and in the final MMPA rule before the exceedance occurs if operational security considerations allow, or as soon as operational security considerations allow after the relevant activity is conducted. Exceedance of an activity level will require the Navy to reinitiate consultation.

13.2 Effects of the Take

In this opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to jeopardize the continued existence or recovery of any ESA-listed species or result in the destruction or adverse modification of designated critical habitat.

13.3 Reasonable and Prudent Measures

Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and term and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the ITS are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

Reasonable and prudent measures are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). The reasonable and prudent measures and terms and conditions are specified as required by 50 CFR 402.12 (i)(1)(ii) and (iv) to document the incidental take by the proposed action and minimize the impact of that take on ESA-listed species. The reasonable and prudent measures are nondiscretionary, and must be undertaken by the Navy and NMFS' Permits Division so that they become binding conditions for the exemption in section 7(o)(2) to apply.

NMFS has determined the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of incidental take of threatened and endangered species during the proposed action:

1. The Navy and NMFS Permits Division shall minimize effects to ESA-listed marine mammals, sea turtles, and fishes from the use of active sonar and other transducers, explosives, and vessels. This includes adherence to the mitigation measures specified in the final MMPA rule and LOA.

2. The Navy and NMFS Permits Division shall monitor and report to NMFS Office of Protected Resources ESA Interagency Cooperation Division on impacts to ESA-listed marine mammals, sea turtles, and fishes from the use of sonar and other transducers, explosives, and vessels. This includes adherence to the monitoring and reporting measures specified in the final MMPA rule and LOA.

3. The Navy shall monitor effects to coral reef habitat at the KWRC from the use of military expended materials and report to NMFS' Office of Protected Resources ESA Interagency Cooperation Division on impacts to ESA-listed corals observed.

13.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the Navy and NMFS Permits Division must comply with the following terms and conditions, which implement the reasonable and prudent measures above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). These terms and conditions are non-discretionary. If the Navy or NMFS Permits Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

1) The following terms and conditions implement reasonable and prudent measure 1:
   a) The Navy shall implement all mitigation measures as specified in the final MMPA rule and LOA, and as described in this opinion in Section 3.4.2.
   b) NMFS' Permits Division shall ensure that all mitigation measures as prescribed in the final rule and LOA, and as described in Section 3.4.2 of this opinion are implemented by the U.S. Navy.
   c) The Navy shall continue technical assistance/adaptive management efforts with NMFS to help inform future consultations on Navy training and testing in the action area. Adaptive management discussions may include potential new measures to increase mitigation effectiveness (e.g., thermal detection of protected species).
2) The following terms and conditions implement reasonable and prudent measure 2:
   a) The Navy shall monitor training and testing activities and submit reports annually to NMFS Permits Division and NMFS ESA Interagency Cooperation Division including the location and total hours and counts of active sonar hours and in-water explosives used, and an assessment if activities conducted in the action area exceeded levels of training and testing analyzed in this opinion annually and over the five year period of the MMPA regulations and LOAs.
   b) NMFS Permits Division shall review the reports submitted by the Navy described above in 2(a). Within two months of receipt of each Navy report, NMFS Permits Division will submit written documentation to NMFS ESA Interagency Cooperation Division assessing if Navy activities conducted in the action area exceeded levels of training and testing analyzed in this opinion annually and over the five-year period of the MMPA regulations and LOAs.
   c) The Navy shall monitor and provide annual reports to NMFS Permits Division and NMFS ESA Interagency Cooperation Division on the total hours and counts of active sonar and in-water explosives used in the southeast North Atlantic right whale critical habitat from 15 November to 15 April, and in the northeast North Atlantic right whale

critical habitat year-round, to ensure activity levels and the nature of activities conducted in these areas are consistent with those analyzed in this biological opinion.

d) NMFS Permits Division shall review the report submitted by the Navy described above in 2(c). Within two months of receipt of each Navy report, NMFS Permits Division will submit written documentation to NMFS ESA Interagency Cooperation Division assessing if activity levels and the nature of activities conducted in the southeast North Atlantic right whale critical habitat from 15 November to 15 April, and in the northeast North Atlantic right whale critical habitat year-round are consistent with those analyzed in this biological opinion.

e) The Navy and NMFS Permits Division shall report to the NMFS ESA Interagency Cooperation Division all observed injury or mortality of any ESA-listed species resulting from the proposed training and testing activities within the action area. The Navy shall report when enough data are available to determine if the dead or seriously injured ESA-listed species may be attributable to these activities, including but not limited to, the use of explosives and vessel strike.

f) In the event that Navy personnel (uniformed military, civilian, or contractors while conducting Navy work) discover a live or dead stranded marine mammal or sea turtle within the action area or on Navy property, the Navy shall report the incident to NMFS immediately or as soon as operational security considerations allow.

g) If NMFS personnel determine that the circumstances of any of the strandings reported in 2(f) suggest investigation of the associated of Navy activities is warranted (see stranding and notification document for example circumstances), and an investigation into the stranding is being pursued, NMFS personnel will submit a written request to the Navy asking that they provide the status of all sound source and explosive use in the 48 hours preceding and within 50 km (27 NM) of the discovery/notification of the stranding by NMFS, or estimated time of stranding. Navy will submit this information as soon as possible, but no later than seven business days after the request.

3) The following terms and conditions implement reasonable and prudent measure 3. The goal of these terms and conditions is to improve identification and analysis of marine debris to determine what component military expended material constitutes the overall amount of debris in the marine environment.

   a) The Navy shall develop a plan, in cooperation with NMFS ESA Interagency Cooperation Division, to coordinate with relevant entities (e.g., National Marine Sanctuaries Program, NOAA Marine Debris program, relevant coral researchers) conducting underwater surveys in or near the KWRC. This plan shall be developed to identify and evaluate the extent to which debris of military origin (i.e., military expended materials) may have impacted ESA-listed corals and designated coral critical habitat. The coordination and evaluation plan should include the following:

b) The Navy will compile existing surface and bottom current data to estimate the most likely patterns of movement of military expended materials from training and testing activities in the KWRC. The Navy will use those estimates to identify a prioritized list of seafloor areas where the potential military expended material movement patterns are most likely to overlap ESA-listed coral and coral critical habitat. This will be based on existing best available mapping data in or near KWRC where ESA-listed corals and their habitat are thought to occur. The Navy will evaluate existing research/data to determine if military expended materials have been documented in those areas and whether any impacts to ESA-listed coral or designated critical habitat from those materials have occurred.

c) The Navy will work with entities already conducting underwater surveys in or near the KWRC to incorporate searches for potential military expended materials in future scheduled surveys to determine if there are any observed impacts on ESA-listed corals or designated coral critical habitat from those materials. The Navy should make available information on the identification of military expended materials to assist researchers in determining whether debris encountered during past and future underwater surveys, if any, could be of military origin.

d) Within 30 days of completion the first year of the proposed action, the Navy will provide a report to NMFS ESA Interagency Cooperation Division on the status of the Navy's effort to evaluate existing data to determine whether there is past evidence of military expended materials impacting ESA-listed coral or designated coral critical habitat. In year three, the Navy will then provide a report, and every two years after, as part of the annual monitoring report on the status of this work, to include a summary of information on the extent to which military expended materials, if any, has been encountered and if there were any observed impacts on ESA-listed corals or designated coral critical habitat from those materials. After five years, based on existing findings, the Navy and NMFS will re-evaluate if any impacts have been observed and the future utility for requiring this Term and Condition.

14 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

1. The Navy should assess the future practicability of implementing vessel speed reductions when operating in Seasonal Management Areas and Dynamic Management Areas.
2. The Navy should assess the future practicability of further minimizing activities using active sonar and explosives in areas with higher North Atlantic right whale occurrence

(e.g., larger portion of North Atlantic right whale designated critical habitat in the southeast U.S.) during times of the year when North Atlantic right whales have been documented in those areas.

3. The Navy should assess the future practicability of observing a 1,000 yard shutdown for North Atlantic right whales and Gulf of Mexico Bryde's whales when using low-frequency active sonar at or above 200 dB and hull-mounted mid-frequency active sonar. NMFS understands that Navy lookouts cannot always differentiate between species of large whales. The recommendation is that the Navy Lookout would call for a shutdown if he/she believes the sighting is likely a North Atlantic right whale or Gulf of Mexico Bryde's whale (i.e., based on identifying physical features, behavior, or location). The recommendation is not that the Navy shutdown for any large whale observed within 1,000 yards that cannot otherwise be identified to species.
4. If not already incorporated, the Navy should discuss risks to ESA-listed sturgeon in the Marine Species Awareness Training.
5. The Navy should continue to invest in the improvement of medium and longer term tagging technology and assist researchers in trying to use telemetry data and on/off range sonar information to determine the behavioral responses of animals to exposures to Navy sonar during actual training and testing activities.
6. The Navy should continue to conduct behavioral response studies aimed at obtaining response data that is more consistent with the received sound levels, distances, and durations of exposure that animals are likely to receive incidental to actual training and testing activities.
7. The Navy should continue to model potential impacts to ESA-listed marine mammals and sea turtles using NAEMO and other relevant models. The Navy should validate assumptions used in risk analyses and seek new information and higher quality data for use in such efforts.
8. The Navy should implement measures to better understand the effectiveness of mitigation proposed by the Navy during sonar and explosive use for minimizing impacts to ESA-listed species.
9. The Navy should coordinate with state and federal resource managers to identify research priorities and carry out actions that aid in the recovery and management of North Atlantic right whales.
10. The Navy should conduct additional aerial surveys in the mid-Atlantic region to detect North Atlantic right whales.
11. The Navy should conduct research regarding the abundance and distribution of ESA-listed fish species in the action area in order to incorporate into Navy density models.

12. The Navy should implement measures to further minimize the marine debris generated during training and testing.

In order for NMFS' Office of Protected Resources Endangered Species Act Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, the Navy and NMFS Permits Division should notify the Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement in their final action.

15 Reinitiation Notice

This concludes formal consultation on the Navy's proposed Phase III Atlantic Fleet Training and Testing activities and NMFS' promulgation of regulations and issuance of incidental take authorizations pursuant to the MMPA. As 50 C.F.R. §402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

(1) The amount or extent of taking specified in the ITS is exceeded.
(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
(3) The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.
(4) A new species is listed, or critical habitat designated under the ESA that may be affected by the action.

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NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL AND CONFERENCE OPINION

Title: Amended Incidental Take Statement for the Biological and Conference Opinion on U.S. Navy Atlantic Fleet Training and Testing and the National Marine Fisheries Service's Promulgation of Regulations Pursuant to the Marine Mammal Protection Act for the Navy to "Take" Marine Mammals Incidental to Atlantic Fleet Training and Testing

Consultation Conducted By: Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Action Agency: United States Department of the Navy

Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Publisher: Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Approved: Donna S. Wieting

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Director, Office of Protected Resources

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13 Incidental Take Statement (Amended October 25, 2019)

[NOTE: To ensure the ITS associated with the October 2018 Biological and Conference Opinion is consistent with NMFS Permits and Conservation Division consideration to issue revised MMPA regulations and new LOAs to account for a two-year extension of the 2018 (existing five-year) AFTT MMPA regulations, we have prepared this amended ITS to cover the seven-year period.]

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. In the case of threatened species, section 4(d) of the ESA leaves it to the Secretary's discretion whether and to what extent to extend the statutory 9(a) ''take'' prohibitions, and directs the agency to issue regulations it considers necessary and advisable for the conservation of the species.

"Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. NMFS had not yet defined "harass" under the ESA in regulation, but has issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering." We considered NMFS' interim definition of harassment in evaluating whether the proposed activities are likely to result in harassment of ESA-listed species. Incidental take statements serve a number of functions, including providing reinitiation triggers for all anticipated take, providing exemptions from Section 9 liability for prohibited take, and identifying reasonable and prudent measures that will minimize the impact of anticipated incidental take.

When an action will result in incidental take of ESA-listed marine mammals, ESA section 7(b)(4) requires that such taking be authorized under the MMPA section 101(a)(5) before the Secretary can issue an ITS for ESA-listed marine mammals and that an ITS specify those measures that are necessary to comply with Section 101(a)(5) of the MMPA. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS, including those specified as necessary to comply with the MMPA, Section 101(a)(5). Accordingly, the terms of this ITS and the exemption from Section 9 of the ESA become effective only upon the issuance of MMPA authorization to take the marine mammals identified here. Absent such authorization, this ITS is inoperative for ESA-listed marine mammals. Recall that this consultation analyzed the effects of two actions: 1) the Navy's Phase III AFTT training and testing activities and 2) NMFS Permits Division's promulgation of regulations pursuant to the MMPA for the Navy to "take" marine mammals incidental to AFTT activities. The amount or extent of take of marine mammals described below are applicable to both the Navy and NMFS Permits Division.

At the time of this consultation, take prohibitions have not been extended to the threatened Central and Southwest Atlantic DPS of scalloped hammerhead shark or the threatened species of Caribbean corals. However, consistent with *CBD v. Salazar*, 695 F.3d 893 (9th Cir. 2012), we assessed the amount or extent of take to these threatened species that is anticipated incidental to Navy training and testing activities and include this information in the ITS. Inclusion of these species in the ITS serves to assist the action agency with monitoring of take and provides a trigger for reinitiation if levels of estimated take are exceeded.

13.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions. Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (e.g., similarly affected species or habitat or ecological conditions) may be used to express the amount or extent of anticipated take.

The following tables list the anticipated take from training and testing activities by species and the interrelated and interdependent actions of issuance of a seven-year regulation[1] and LOAs by NMFS' Permits Division to authorize take of marine mammals pursuant to the MMPA.

[1] On November 14, 2018, NMFS issued a five-year final rule governing the taking of marine mammals incidental to Navy training and testing activities conducted in the AFTT Study Area (83 FR 57076; hereafter "2018 AFTT final rule"). Previously on August 13, 2018, and towards the end of the time period in which NMFS was processing the Navy's request for the 2018 regulations, the 2019 NDAA amended the MMPA for military readiness activities to allow incidental take regulations to be issued for up to seven years instead of the previous five years. On May 13, 2019 NMFS issued a proposed seven-year rule and associated Letters of Authorization (LOAs) to cover the same activities covered by the 2018 AFTT regulations (84 FR 21126).

Table 1. The number of lethal and non-lethal takes of threatened and endangered marine mammals, sea turtles, and fish likely to occur annually (except in the case of mortality from ship strike) as a result of the proposed Navy training and testing activities in the action area.

ESA-Listed Species	Impulsive and Non-Impulsive Acoustic Stressors				Vessel Strike	
	Harassment (TTS/Behavioral)	Harm (PTS)	Harm (Slight Lung Injury)	Mortality	Mortality[1] (over every 7 year period)	Harm (non-lethal injuries)
Cetaceans						
North Atlantic Right Whale	266 / 203	-	-	-	-	-
Blue Whale	34 / 12	-	-	-	-	-
Bryde's Whale – Gulf of Mexico subspecies[1]	28 / 24	-	-	-	-	-
Fin Whale	3,437 / 1,716	6	-	-	1	-
Sei Whale	529 / 245	-	-	-	1	-
Sperm Whale	682 / 25,810	-	-	-	1	-
Sea Turtles						
Green – North Atlantic DPS	40/5,076	6	-	-	77	4
Hawksbill	313/24	-	-	-	-	4
Kemp's ridley	28/6,660	5			28	5
Loggerhead	772/46,178	80	17	2	105	11
Leatherback	348/3,299	22	2	-	7	3

ESA-Listed Species	Impulsive and Non-Impulsive Acoustic Stressors				Vessel Strike	
	Harassment (TTS/Behavioral)	Harm (PTS)	Harm (Slight Lung Injury)	Mortality	Mortality[1] (over every 7 year period)	Harm (non-lethal injuries)
Fishes						
Atlantic Sturgeon – Gulf of Maine DPS Atlantic Sturgeon – New York Bight DPS Atlantic Sturgeon – Chesapeake Bay DPS Atlantic Sturgeon – Carolina DPS Atlantic Sturgeon – South Atlantic DPS	*See paragraph below regarding the extent of take of ESA-listed fish from the proposed action*				No more than 6 across all DPSs combined No more than 1 each from Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS	-
Gulf sturgeon	*See paragraph below regarding the extent of take of ESA-listed fish from the proposed action*				1	-
[1]Numbers presented represent total exempted over every seven-year period. In the effects analyses for this biological opinion (Section 9.2), we estimated the annual						

Table 2. The number of lethal and non-lethal takes of threatened and endangered marine mammals and sea turtles likely to occur as a result of exposure to small ship shock trials conducted in the action area (i.e., up to three small ship shock trials could occur every seven years).

ESA-Listed Species	Small Ship Shock Trials			
	Harassment (TTS)	Harm (PTS)	Harm (Slight Lung Injury)	Mortality
Marine Mammals				
North Atlantic Right Whale	3	-	-	-
Blue Whale	-	-	-	-
Bryde's Whale – Gulf of Mexico subspecies [1]	-	-	-	-
Fin Whale	393	9	-	-
Sei Whale	36	3	-	-
Sperm Whale	3	3	-	-
Sea Turtles				
Green – North Atlantic DPS	18	1	-	-
Hawksbill	2	-	-	-
Kemp's ridley	12	1	1	-
Loggerhead	339	19	5	1
Leatherback	169	7	1	-

[1]Gulf of Mexico Bryde's whale was proposed for listing at the time this biological opinion was completed. On April 15, 2019 NMFS published a final rule to list this species as

Table 3. The number of lethal and non-lethal takes of threatened and endangered marine mammals and sea turtles that are likely to occur as result of exposure to a large ship shock trial conducted once every seven years in the action area.

ESA-Listed Species	Large Ship Shock Trial			
	Harassment (TTS)	Harm (PTS)	Harm (Slight Lung Injury)	Mortality
Marine Mammals				
North Atlantic Right Whale	2	-	-	-
Blue Whale	1	-	-	-
Bryde's Whale – Gulf of Mexico subspecies[1]	3	1	-	-
Fin Whale	234	27	-	-
Sei Whale	27	4	-	-
Sperm Whale	3	3	1	-
Sea Turtles				
Green – North Atlantic DPS	18	1	-	-
Hawksbill	2	1	-	-
Kemp's ridley	15	1	1	-
Loggerhead	283	13	4	1
Leatherback	215	7	2	-

[1]Gulf of Mexico Bryde's whale was proposed for listing at the time this biological opinion was completed. On April 15, 2019 NMFS published a final rule to list this species as endangered under the ESA (effective date May 15, 2019).

When it is not possible or practicable to specify the amount or extent of take, a surrogate may be used if we: describe the causal link between the surrogate and take of the listed species, explain why it is not practical to express the amount or extent of anticipated take or to monitor take-related impacts in terms of individuals of the listed species, and set a clear standard for determining when the level of anticipated take has been exceeded. 50 C.F.R. 402.14(g)(7)(i). As described previously in Section 9.2.3, for the proposed action, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take of ESA-listed fish species or to monitor take-related impacts in terms of individuals of these species due to the lack of data on fish density and abundance in the action area. Therefore, the surrogate for incidental take of ESA-listed fishes is expressed as a distance to reach effects in the water column that correlates with injury and sub-injury from acoustic stressors in those areas occupied by fishes. In other cases, as with vessel strikes we provide relative percentage of potential take for Atlantic sturgeon DPSs in relation to Navy vessel traffic occurrence within the action area (See Table 1).

As described previously in Section 9.2.4, for the proposed action, it is not possible, nor would it be an accurate representation of likely effects, to express the amount of anticipated take of ESA-listed corals as numbers of colonies, or to monitor take-related impacts in terms of individual colonies of these species. Therefore, the incidental take of ESA-listed corals is expressed as a habitat area surrogate as prescribed by 50 CFR 402.14(i). Anticipated take of ESA-listed corals is 0.00003 km^2 of habitat annually that may be occupied by live hard coral cover, a subset of which would be occupied by ESA-listed corals. This area of live coral cover is likely to be vulnerable to impacts from military expended materials used during training and testing activities.

Activity Levels as Indicators of Take for Marine Mammals and Sea Turtles

As discussed in this opinion, the estimated take of ESA-listed sea turtles and marine mammals from acoustic stressors is based on Navy modeling, which represents the best available means of numerically quantifying take. As the level of modeled sonar or explosive use increases, the level of take is likely to increase as well. For non-lethal take from acoustic sources specified above, feasible monitoring techniques for detecting and calculating actual take at the scale of AFTT activities do not exist. We are not aware of any other feasible or available means of determining when estimated take levels may be exceeded. Therefore, we must rely on Navy modeling, and the link between sonar or explosive use and the level of take, to determine when anticipated take levels have been exceeded. As such, we established a term and condition of this Incidental Take Statement that requires the Navy to report to NMFS any exceedance of activity specified in the preceding opinion and in the final MMPA rule before the exceedance occurs if operational security considerations allow, or as soon as operational security considerations allow after the relevant activity is conducted. Exceedance of an activity level will require the Navy to reinitiate consultation.

13.2 Effects of the Take

In this opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to jeopardize the continued existence or recovery of any ESA-listed species or result in the destruction or adverse modification of designated critical habitat.

13.3 Reasonable and Prudent Measures

Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and term and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the ITS are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

Reasonable and prudent measures are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). The reasonable and prudent measures and terms and conditions are specified as required by 50 CFR 402.12 (i)(1)(ii) and (iv) to document the incidental take by the proposed action and minimize the impact of that take on ESA-listed species. The reasonable and prudent measures are nondiscretionary, and must be undertaken by the Navy and NMFS' Permits Division so that they become binding conditions for the exemption in section 7(o)(2) to apply.

NMFS has determined the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of incidental take of threatened and endangered species during the proposed action:

1. The Navy and NMFS Permits Division shall minimize effects to ESA-listed marine mammals, sea turtles, and fishes from the use of active sonar and other transducers, explosives, and vessels. This includes adherence to the mitigation measures specified in the final MMPA rule and LOA.

2. The Navy and NMFS Permits Division shall monitor and report to NMFS Office of Protected Resources ESA Interagency Cooperation Division on impacts to ESA-listed marine mammals, sea turtles, and fishes from the use of sonar and other transducers, explosives, and vessels. This includes adherence to the monitoring and reporting measures specified in the final MMPA rule and LOA.

3. The Navy shall monitor effects to coral reef habitat at the KWRC from the use of military expended materials and report to NMFS' Office of Protected Resources ESA Interagency Cooperation Division on impacts to ESA-listed corals observed.

13.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the Navy and NMFS Permits Division must comply with the following terms and conditions, which implement the reasonable and prudent measures above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). These terms and conditions are non-discretionary. If the Navy or NMFS Permits Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

1) The following terms and conditions implement reasonable and prudent measure 1:
    a) The Navy shall implement all mitigation measures as specified in the final MMPA rule and LOA, and as described in this opinion in Section 3.4.2.
    b) NMFS' Permits Division shall ensure that all mitigation measures as prescribed in the final rule and LOA, and as described in Section 3.4.2 of this opinion are implemented by the U.S. Navy.
    c) The Navy shall continue technical assistance/adaptive management efforts with NMFS to help inform future consultations on Navy training and testing in the action area. Adaptive management discussions should include review of Navy's exercise and monitoring reports, review of ESA section 7 reinitiation triggers (described in Section 15), and potential new measures to increase mitigation effectiveness (e.g., thermal detection of protected species)
2) The following terms and conditions implement reasonable and prudent measure 2:
    a) The Navy shall monitor training and testing activities and submit reports annually to NMFS Permits Division and NMFS ESA Interagency Cooperation Division including the location and total hours and counts of active sonar hours and in-water explosives used, and an assessment if activities conducted in the action area exceeded levels of training and testing analyzed in this opinion annually and over the seven-year period of the MMPA regulations and LOAs.
    b) NMFS Permits Division shall review the reports submitted by the Navy described above in 2(a). Within two months of receipt of each Navy report, NMFS Permits Division will submit written documentation to NMFS ESA Interagency Cooperation Division assessing if Navy activities conducted in the action area exceeded levels of training and testing analyzed in this opinion annually and over the seven-year period of the MMPA regulations and LOAs.
    c) The Navy and NMFS Permits Division shall monitor and provide annual reports to NMFS Permits Division and NMFS ESA Interagency Cooperation Division on the total hours and counts of active sonar and in-water explosives used in the southeast North

Atlantic right whale critical habitat from 15 November to 15 April, and in the northeast North Atlantic right whale critical habitat year-round, to ensure activity levels and the nature of activities conducted in these areas are consistent with those analyzed in this biological opinion.

d) NMFS Permits Division shall review the report submitted by the Navy described above in 2(c). Within two months of receipt of each Navy report, NMFS Permits Division will submit written documentation to NMFS ESA Interagency Cooperation Division assessing if activity levels and the nature of activities conducted in the southeast North Atlantic right whale critical habitat from 15 November to 15 April, and in the northeast North Atlantic right whale critical habitat year-round are consistent with those analyzed in this biological opinion.

e) The Navy and NMFS Permits Division shall report to the NMFS ESA Interagency Cooperation Division all observed injury or mortality of any ESA-listed species resulting from the proposed training and testing activities within the action area. The Navy shall report when enough data are available to determine if the dead or seriously injured ESA-listed species may be attributable to these activities, including but not limited to, the use of explosives and vessel strike.

f) In the event that Navy personnel (uniformed military, civilian, or contractors while conducting Navy work) discover a live or dead stranded marine mammal or sea turtle within the action area or on Navy property, the Navy shall report the incident to NMFS immediately or as soon as operational security considerations allow.

g) If NMFS personnel determine that the circumstances of any of the strandings reported in 2(f) suggest investigation of the associated of Navy activities is warranted (see stranding and notification document for example circumstances), and an investigation into the stranding is being pursued, NMFS personnel will submit a written request to the Navy asking that they provide the status of all sound source and explosive use in the 48 hours preceding and within 50 km (27 NM) of the discovery/notification of the stranding by NMFS, or estimated time of stranding. Navy will submit this information as soon as possible, but no later than seven business days after the request.

3) The following terms and conditions implement reasonable and prudent measure 3. The goal of these terms and conditions is to improve identification and analysis of marine debris to determine what component military expended material constitutes the overall amount of debris in the marine environment.

   a) The Navy shall develop a plan, in cooperation with NMFS ESA Interagency Cooperation Division, to coordinate with relevant entities (e.g., National Marine Sanctuaries Program, NOAA Marine Debris program, relevant coral researchers) conducting underwater surveys in or near the KWRC. This plan shall be developed to identify and evaluate the extent to which debris of military origin (i.e., military expended materials) may have impacted ESA-listed corals and designated coral critical habitat. The coordination and evaluation plan should include the following:

b) The Navy will compile existing surface and bottom current data to estimate the most likely patterns of movement of military expended materials from training and testing activities in the KWRC. The Navy will use those estimates to identify a prioritized list of seafloor areas where the potential military expended material movement patterns are most likely to overlap ESA-listed coral and coral critical habitat. This will be based on existing best available mapping data in or near KWRC where ESA-listed corals and their habitat are thought to occur. The Navy will evaluate existing research/data to determine if military expended materials have been documented in those areas and whether any impacts to ESA-listed coral or designated critical habitat from those materials have occurred.

c) The Navy will work with entities already conducting underwater surveys in or near the KWRC to incorporate searches for potential military expended materials in future scheduled surveys to determine if there are any observed impacts on ESA-listed corals or designated coral critical habitat from those materials. The Navy should make available information on the identification of military expended materials to assist researchers in determining whether debris encountered during past and future underwater surveys, if any, could be of military origin.

d) Within 30 days of completion the first year of the proposed action, the Navy will provide a report to NMFS ESA Interagency Cooperation Division on the status of the Navy’s effort to evaluate existing data to determine whether there is past evidence of military expended materials impacting ESA-listed coral or designated coral critical habitat. In year three, the Navy will then provide a report, and every two years after, as part of the annual monitoring report on the status of this work, to include a summary of information on the extent to which military expended materials, if any, has been encountered and if there were any observed impacts on ESA-listed corals or designated coral critical habitat from those materials. After five years, based on existing findings, the Navy and NMFS will re-evaluate if any impacts have been observed and the future utility for requiring this Term and Condition.